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J. MOLLISON C.S.I., M.R.A.C.,
First Inspector-General of Agriculture in India.

Original Articles.

RAINFALL, IRRIGATION AND THE SUBSOIL WATER LEVEL OF THE GANGETIC PLAIN IN THE UNITED PROVINCES OF AGRA AND OUDH.

BY

C. H. HUTTON, M.I.C.E.,

Lately Chief Engineer, P.W.D., Irrigation Branch, U.P.

In the January (1917) Number of this *Journal* Mr. E. A. Molony, I.C.S., calls attention to the great importance of well irrigation in the United Provinces, and in support thereof gives figures to show that nearly 58 per cent. of the total area irrigated is from wells; he also states that the increase in well irrigation, due to the very considerable activity displayed for a good many years past, more especially since the severe famine of 1896-97, both in the construction of new wells and in the improvement of existing wells by boring, has been as much as 52 per cent.

In connection with these facts and in view of the very general complaint heard of late years that the ground-water level is seriously falling, he raises the question as to "whether the underground water supply can stand permanently the existing drain on it, to say nothing of the much greater drain which the vigorous construction of wells, the systematic boring of existing wells, the sinking of modern tube wells of large diameter, and the introduction of mechanical power for lifting water are likely to impose." After discussing the problem he comes to the conclusion that, owing to the increased draught on the subsoil water from the increase in the

number of wells, and also to the more economical distribution of canal water, "the net annual addition to the subsoil water supply is now considerably less than it was 20 years ago," and he concludes from this "that there is a permanent tendency towards a fall in the subsoil water level."

Finally, he suggests certain possible remedies or palliatives to counteract this tendency. A permanent fall in the water level of 10 feet or more would no doubt place out of action or seriously reduce the inflow of a large number of existing *kutcha* and *pucca* wells since, for the most part, they are sunk to no great depth below the subsoil water level.

The question, therefore, which Mr. Molony raises, is of such great importance to the agricultural prosperity of these provinces, more especially of Oudh which at present is without canal irrigation, that I may perhaps be excused if I endeavour to throw further light on the subject.

In order to show more clearly the expansion of irrigation which has taken place within the last 20 years, instead of taking the whole of the Provinces as Mr. Molony has done, I have selected two tracts :—

(1) The canal-irrigated tract in the province of Agra, comprising the districts of Saharanpur, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Muttra, Agra, Etah, Mainpuri, Farrukhabad, Etawah, Cawnpore, Fatehpur, and Allahabad. All these 14 districts are irrigated from one or other of the canals—Ganges, Lower Ganges, Eastern Jumna, and Agra. This latter canal also irrigates in the Delhi and Gurgaon districts outside these provinces.

(2) The well-irrigated tract in Oudh, comprising the 11 districts of Shahjahanpur, Pilibhit, Lucknow, Unao, Rae Bareli, Sitapur, Hardoi, Kheri, Sultanpur, Partabgarh, and Barabanki, all of which lie in the Ganges-Sarda Doab. These districts have been selected as being those, with possibly one or two exceptions, into which irrigation by means of a canal from the Sarda river is likely to be introduced in the near future : this tract is moreover typical of the best well-irrigated part of these provinces.

I have also selected for comparison the famine years of 1896-97 and 1907-08 for the reason that, in years of such severe drought as

these, the utmost use is made of all possible sources of irrigation, and a comparison therefore offers the best possible index of the increased measure of protection against famine afforded by the extension of canal and well irrigation. The climatic conditions in both these years were very similar. In the canal and well-irrigated tracts the total rainfall in 1896-97 was 16·8 and 22·4 inches, and in 1907-08, 17·26 and 20·86 inches respectively. The monsoon of 1896 began on 15th June and ended on 27th August : in the following cold weather 0·2—0·6 inch of rain fell in November, 0·2—1·0 inch in December, and about the same amount again in January. The monsoon of 1907 began during the third week of July and ended in the last week of August ; in the following winter some useful showers fell in January and February. Although the total rainfall of each year was practically the same, the monsoon of 1907 lasted only five weeks and the following winter rains were not only later but smaller in amount so that on the whole it may be said that the drought of 1907-08 was the more severe from an agricultural point of view.

The Canal-irrigated Tract.

Table I (pp. 204-5) gives the agricultural and irrigation statistics of this tract for 1896-97 and 1907-08.

The Agricultural Department's records for 1896-97 do not show the total area irrigated. This has been interpolated by me in the following manner : the total canal-irrigated area is known from the Irrigation Department's records and an addition equivalent to a percentage derived from the figures for 1907-08 has been made to the total *ek-fasli* area irrigated from wells and other sources ; the two added together give the total area irrigated during the year very approximately.

Comparing the *ek-fasli* figures for irrigation from wells and other sources, since there is unfortunately no record of the corresponding *do-fasli* figures, we find that in 1907-08 well irrigation decreased by 0·2 per cent. ; this is somewhat surprising if the figures for the number of wells available in each year be compared. The well figures for 1896-97 are not, however, believed to be very accurate

and the number of wells actually in use has not been recorded. There has been, it is believed, a small increase in the number of wells constructed for irrigation purposes, but nothing comparable to the increase since 1896-97 in the well tract. That the figures show a small decrease must be due to canal extensions such as the Mat and Fatehpur branches resulting in the displacement of well by canal irrigation, and also in some measure to the reduced supply in some of the wells in 1907-08 owing to the fall in the ground-water level. The figures for 1907-08 show an increase of 14·8 per cent. in canal irrigation and of 8·3 per cent. in the total area irrigated.

When the monsoon ends as prematurely as it did in 1896-97 and 1907-08, the lack of moisture in the soil necessitates irrigation for the preparation of the seed bed for the winter crops; the valuable sugarcane crop too requires a watering at the same time. Hence the available supplies in the canals during the months of October and November, the season for the sowing of the *rabi* crops, determine the *rabi* area irrigated from the canals. The supplies during these two months were lower in 1907-08 than in 1896-97 and also throughout the *rabi* season: the average daily discharge at the heads of the canals "utilized" throughout the *rabi* was 9,986 *cusecs* in 1896-97 and 8,814 *cusecs* or 1,172 *cusecs* less in 1907-08.

The depths of water on the irrigated area based on the utilized discharges at the heads of the canals were as follows:—For the *kharif* 2·80 and 2·52 feet, for the *rabi* 2·17 and 1·79 feet, and for the whole year 2·41 and 2·11 feet respectively. The depth of 2·11 feet is equivalent to a depth of 0·45 foot over the gross area commanded by the canals, *viz.*, 14,704,000 acres.

The reduction in the *rabi* depth is to a certain extent a measure of the economy effected in the distribution of water, but it is not an absolute measure, as in such years two waterings at least in addition to the *paleo* are required for the proper maturing of the crop, and so many with a diminishing supply it is not possible to give to the whole area which has received a *paleo* watering. In 1907-08 for this reason partial or full remissions had to be granted on some 7 per cent. of the area *paleoed*, which figure was probably larger than that for 1896-97.

As far as I am aware, there has been no such serious fall of the ground-water level in this tract as to cause anxiety to the irrigators from wells, although the fall which is the natural result of a sequence of dry years has been well marked. The fall, moreover, has to some extent been lessened by the more continuous running of the canals on account of the drought, resulting in increased see page therefrom.

In the case of this tract, therefore, the main question does not appear to me to arise and the palliative measures proposed by Mr. Molony need not in consequence be considered.

The only tract within the area commanded by canals, and not a very large one, with which I am acquainted, in which there has undoubtedly been a considerable and permanent fall in the ground-water level, is that lying along the Karon Naddi in the Muttra District and may be referred to here as bearing on this question.

In order to relieve excessive flooding which occurred higher up this valley in the Aligarh District some time in the eighties, the channel of the Karon Naddi was rectified and improved. In my opinion the fall in the ground-water level which has since been observed is chiefly due to the quick removal of the water which previously accumulated in widespread depressions within the catchment area of this Naddi and, in some small degree also, to the deepening of the channel by erosion and not, as has been often suggested, to the abstraction of water from the Jumna, which runs at a distance of some 14 miles parallel to this tract, by the Jumna canals.

For the past 30 years or so the Irrigation Department has kept annual records of the rise and fall of the ground-water along various lines across the Jumna-Ganges Doab, roughly at right angles to the general slope of the country from west to east. These observations are made twice a year, in November when the level may be expected to be at its highest and in May when it may be expected to be at its lowest ; they are made at suitable non-irrigation wells at intervals of two or three miles along these lines.

When the writer was Chief Engineer in the United Provinces the question of a Sarda Canal for Oudh again came to the front and similar observations were ordered to be made across the

Ganges-Sarda Doab and these, if the canal is made, should afford valuable information as to its effect on the ground-water level.

In the case of the Jumna-Ganges Doab the observations were unfortunately not instituted until some years after the construction of the canals as their importance was not then recognized. It is known, however, that the rise due to seepage from the canals, especially in their proximity, has been considerable.

The main object of these observations is to enable the Canal Engineer to watch the rise of the subsoil water level in order to be ready to adopt certain measures, such as surface drainage, restricted irrigation, etc., to counteract the combined effect of rainfall, irrigation, and seepage in unduly raising this level.

It was not realized until some time after the introduction of canal irrigation into these provinces that the water poured on to the land, in addition to the seepage from canal channels, not only tended to raise the ground-water level unduly, which led to water-logging in low-lying tracts, but also rendered the soil less capable of absorbing the natural rainfall, which led to serious flooding in wet seasons. During a series of wet years in the eighties the resultant evils became so serious and created such an outcry against the canals that extensive drainage measures were undertaken, consisting in the improvement of the natural drainage channels and the construction of many miles of surface drains. These measures have proved entirely satisfactory and but few complaints of water-logging or flooding being due to the canals are now heard of.

In confirmation of this I need but instance the deplorable condition of the Farrukhabad District in the eighties after a cycle of wet years as compared with its present condition since extensive drainage works were carried out by the Irrigation Department. It has been, however, conclusively proved by the late Mr. J. R. C. Nicolls (*vide* his Report on the Kali Naddi Drainage) that canal irrigation as compared with the excessive rainfall played but a minor part in the deterioration of that district.

It is suggested by Mr. Molony as a matter for serious consideration whether the policy of surface drainage has not been carried too far by the Irrigation Department.

In regard to the natural phenomena such as rainfall, floods, and climate it has been truly said that men's memories are very short. There is no proof whatever that the climate of India is changing, the law of averages must prevail, and the recent cycle of dry years will be followed, as surely as the night follows the day, by a cycle of wet years. The United Provinces are frequently subject to cyclonic storms with heavy rainfall towards the close of the monsoon, which occasion widespread flooding. I have a very clear recollection of such a storm in the first fortnight of October 1903 which, fn some three or four days, gave the extraordinarily heavy rainfall of 18 to 20 inches over the whole of the area commanded by the Lower Ganges Canal, some 10,500 sq. miles, and was the cause of serious and extensive flooding; nevertheless the drains constructed by the Irrigation Department afforded such relief that practically the whole of the area could be prepared for the *rabi*. Had this not been the case the ground in many parts would have become water-logged, the ground-water level unduly raised, and thousands of acres must have remained unsown. Clearly it is not the case here that the country has been over-drained, and, if a longer view be taken in anticipation of the inevitable return of a cycle of wet years such as has come within my experience, it will not be found that the country has been over-drained.

(*To be continued.*)

TABLE

Year	Rainfall	Total area	Normal cultivated area	Not available for cultivation	Canal irrigation	Well irrigation	Irrigation from other sources	Total *ek-fasli* irrigated area
	Ins.	Acres	Acres	Acres	Acres	Acres	Acres	Acres
								CANAL TRACT (nor
1896-97 ...	16·80				1,817,679	2,333,189	146,289	4,297,157
						2,479,478		
					843,269	11½%	285,139	
					2,660,948	2,764,617		
		17,206,635	10,960,000	Forests 191,339				
				3,082,362				
				Total 3,273,701				
1907-08 ..	17·26				2,310,802	2,328,188	233,389	4,892,379
						2,561,577		
					745,560	300,465		
					3,056,362	2,862,042		
Difference ...	+0 46				+395,414	+97,425		+ 595,222
					+14·8%	+3·5%		+ 13·9%
								WELL TRACT (nor
1896-97 ...	22·40				15,595	1,361,215	439,891	1,816,701
						1,801,106		
					5,731	9½%	171,105	
					21,326	1,972,211		
		12,832,748	7,523,000	Forests 392,166				
				1,875,553				
				Total 2,267,719				
1907-08 ..	20·86				16,715	2,034,068	354,868	2,405,651
						2,388,936		
					5,356	226,781		
					22,071	2,615,717		
Difference ...	−1·54				+745	+ 643,506		+588,950
						+ 32·6%		+32·4%

I.

Total annual irrigated area	Total cropped area	*Do-fasli* area	Masonry Wells		Non-Masonry Wells		Canal Irrigation	
			In use	Available	In use	Available	Kharif and Sugar	Rabi
Acres	Acres	Acres	No.	No.	No.	No.	Acres	Acres
mal rainfall 30·14 ins.)								
5,425,565	11,627,343	2,139,896	?	112,725	?	316,828	1,047,819	1,614,187
5,918,404	11,699,788	1,901,559	133,616	164,244	306,898	357,601	1,325,402	1,724,960
+492,839 +8·3%	+72,445 +0·6%	−238,337 −11·1%	?	+51,519	?	+40,773	+277,583 +26·5%	+110,773 +6·8%
mal rainfall 38·60 ins.)								
1,993,537	8,162,058	1,594,096	?	68,072	?	272,396	11,841	9,485
2,637,788	8,446,250	1,138,903	108,978	117,279	561,079	572,283	10,409	11,662
+644,251 +32·3%	+284,192 +3·5%	−455,193 −28·5%	?	+49,207	?	+299,887	−1,432	+2,177

THE PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY.

BY

W. A. DAVIS, B. Sc., A. C. G. I.,

Indigo Research Chemist to the Government of India.

(Continued from page 46, Vol. XIII, Pt. I.)

II. Present Methods of Manufacture in Bihar.

Although since the war, the actual output of indigo from the Madras Presidency, the United Provinces, and the Punjab has considerably exceeded that of Bihar * the manufacturing methods in use in the former provinces are much inferior to those employed in Bihar. In Bihar the manufacture of indigo is in the hands of large concerns, often producing 500 to 1,000 maunds of cake indigo in the season, and equipped with steam-power and under European supervision. In the other provinces the industry is with a few exceptions carried out by small village operatives using comparatively primitive methods which give a relatively poor yield of dye and a low quality product. Before the war the manufacture of indigo had practically ceased in all parts of India except Bihar. The quality of natural indigo is an important factor in determining its use by the dyer, and the low grade indigo of Madras and the other provinces (often deliberately adulterated) was gradually excluded from the world's markets by the high quality synthetic indigo of the German manufacturers. In the present article the methods actually in use in Bihar will be described ; it will then be practicable to consider the defects existing in these and the possibility of effecting improvements in both agriculture and manufacture.

* See Table VI, page 41, Vol. XIII, Pt. I of this *Journal*.

The Indigo Plant.

Two species of indigo are cultivated in Bihar :—

(a) *Indigofera Sumatrana,* or Sumatrana plant.

(b) *Indigofera arrecta,* or Natal-Java plant, generally called now simply " Java plant."

The *Sumatrana plant* is still the principal form of indigo grown in the United Provinces, Madras, and the Punjab, and the seed of the Sumatrana plant grown in Bihar is obtained from the United Provinces. The plant is not grown at all for seed in Bihar, as the conditions appear to be less favourable than in the United Provinces.

The *Java plant* was introduced into Bihar by Mr. H. A. Bailey, who visited Java in 1899 on behalf of the Indigo Improvements Syndicate which was at the time carrying out experimental work under the direction of Bernard Coventry at Dalsing Sarai. In the two or three years following 1901, experimental work was carried out to ascertain the best methods of sowing and cultivating this plant in Bihar and of obtaining seed. About 1904 its cultivation was taken up generally in Bihar, and it was rapidly superseding the Sumatrana plant, when certain peculiar difficulties were encountered, with which I shall have to deal in detail later.

From the large number of trials made by Rawson (*Report to the Bihar Planters' Association*) during the years 1900-1902, the yield of 60 per cent. indigo from the Sumatrana plant varied from 6 to 12 seers per 100 maunds of average green plant. There is no doubt that the *quality of the soil* on which the plant is grown largely influences not merely the actual yield of green plant (a point to be considered later), but also its quality. Thus the trials made by Rawson showed that the Sumatrana plant grown on old *zerat* lands (lands held and cultivated by the factories) gave a considerably lower yield of indigo per 100 maunds of plant than on *zillah* lands (lands worked by ryots and not systematically stripped by growing one crop—indigo—continuously). Thus the average yield in Rawson's trials with *zillah* plant in two seasons was 11·6 seers per 100 maunds, whereas with *zerat* plant the average was only 5·1 seers, or less than half. This difference is all the more striking, bearing

in mind the fact that the *zerat* lands have generally greater advantages in the way of better cultivation by superior implements than the *zillah* lands cultivated by the ryots. At the present time, from returns sent in to me from different factories for the season 1916-17, the average yield of 60 per cent. indigo per 100 maunds of green Sumatrana plant may be taken as 8 to 9 seers.

The Java species not only yields, as a rule, far more green plant per acre than the Sumatrana indigo, but far more dye per 100 maunds of plant. The early experiments made by Francis Coventry at Dalsing Sarai in 1905 gave the following results *for the first cutting only :—*

Plant	Area grown Acres	Mds. cake indigo produced	Indigo per 100 maunds plant		Seers indigo per acre		Mds. green plant per acre
			s.	ch.	s.	ch.	
Sumatrana	2,130	326	8	12½	6	2	70
Java ..	571	171½	13	6	12	0	91

There is an increase with the Java plant of 30 per cent. in maunds of green plant per acre, of 50 per cent. on the yield of indigo per 100 maunds of plant, and of over 90 per cent. on the yield of cake indigo per acre.

Bergtheil in his *Reports of the Sirsiah Indigo Research Station* of 1906 and 1907 gives the following comparative results with the two kinds of plant ; in these seasons returns were made to him of the actual results obtained by the indigo factories of Bihar working both forms of plant on the large scale.

Year	Concern		Average yield *cake indigo* per acre		Average yield per 100 maunds plant	
			s.	ch.	s.	ch.
1906	Average of 20 indigo factories	Java	14	6	14	13
		Sumatrana	10	15	12	4
	Sirsiah	Java	———	———	17	0
1907	Average of 31 indigo factories	Java	20	9	15	0
	Sirsiah	,,	19	3	16	1

Thus the *average* from 20 factories in 1906 showed an increase with the Java plant of nearly 40 per cent. in the yield of cake indigo per acre, and an increase of about 20 per cent. in the yield per 100 maunds of plant. The average yield of indigo per acre is considerably higher than the yield per acre obtained by Francis Coventry at Dalsing Sarai; but it must be remembered that the Dalsing Sarai figures give only the results of a single cutting (*moorhan*) whilst the figures above refer to the whole season's make (*moorhan* and *khoonties*). The difference in the produce per 100 maunds of green plant is not so apparent in the average returns from the factories as at Dalsing Sarai, but the average factory value, 12·4, obtained for Sumatrana plant in 1906 is unusually high and the value for Java plant unusually low. The returns sent me by factories for the year 1916 showed the *average* yield for the whole season per 100 maunds for Sumatrana plant to be 8 to 9 seers, whilst for Java plant it was 16 to 18 seers. In most factories for which I have returns, the produce per 100 maunds was 50 to 100 per cent. higher than for Sumatrana, which bears out the results obtained at Dalsing Sarai in 1905.

Actual analyses have shown that whilst the Sumatrana plant at the time of *mahai* contains on the average from 0·4 to 0·6 per cent. of indigotin *in the leaf*, good Java plant contains nearly double this amount, *viz.*, from 0·8 to 1 per cent. of indigotin. The percentage of leaf on the total weight of the plant put into the vat is, too, generally somewhat higher with Java plant (about 50 per cent.) than with the Sumatrana plant (40 per cent.). As the actual yield of green plant per acre for good Java indigo is 30 per cent. higher than for Sumatrana and the plant is frequently twice as rich in indigotin, it can easily be understood that the yield of cake indigo *per acre*, which is the principal consideration for the planter, is frequently more than twice as great with the Java plant as with the old Sumatrana plant.

The great importance is therefore obvious of increasing the cultivation of the Java plant in place of the old Sumatrana in order to cheapen production and so enable natural indigo to compete with synthetic in price. Unfortunately, however, serious difficulties

have been encountered in the past few years in extending the cultivation of the Java plant. These difficulties and the means by which they can be overcome will be dealt with in detail later.

Cultivation and Sowing.

The Java indigo plant is usually sown in Bihar about the middle of October after the rains have ceased. The plant germinates in a short time, but during the cold weather there is little growth—by January it is only a few inches high—but when the warm weather comes it develops rapidly, and by May or June is ready for the first cutting—the *moorhan* crop—of leaf for manufacture. It is usually cut down at this time to about six inches from the ground, and is then left for another month or six weeks for a second crop of leaf. If the soil is a good one, the stumps send out vigorous shoots which grow rapidly and give a good leaf crop—the so-called *khoontie* crop or second cutting.

In districts which are subject to early flooding in July or in August, it has been found to be a great advantage to sow the Java crop as early as possible, *viz.*, in September instead of October, if the state of the land after the cessation of the rains makes cultivation possible. The plant is then ready for the first *mahai* much earlier, namely, by April or May, and a second cutting can be obtained in June or July before the floods come and destroy the *khoonties*. In this way some factories which habitually lost *khoonties* by early flooding have been able to secure an early second cutting.

The Sumatrana plant is usually sown about the middle of February, either after a fallow or after a *rabi* crop. If Sumatrana plant is sown in October or November it does not thrive, probably owing to its being unable to withstand cold weather, and a large proportion dies out.

Before sowing the fields have to be thoroughly prepared. The land is first hoed to remove weeds, and is then ploughed by means of bullock-drawn ploughs which first furrow lengthwise and then across at right angles. After ploughing the soil is broken up and smoothed by means of a *hanga*, which is a heavy wooden log drawn

by a pair of bullocks. The land is a few days later ploughed again, and the soil again broken up and smoothed by the *hanga*. These operations may be repeated three or four times. The surface soil is thus brought into a finely powdered, loose condition, which affords a good seed bed, whilst the compacting of the surface allows of the capillary rise of moisture and prevents rapid evaporation. The sowing is generally effected in lines by means of simple drills which distribute the seed at proper intervals. Generally with Java plant the sowing for a leaf crop is at the rate of 5 to 6 seers of seed per acre, but with Sumatrana seed a larger quantity is required, *viz.*, 8 to 12 seers per acre. The exact quantity of seed will be regulated by the germination of the seed, and with a seed germinating 100 per cent. a smaller quantity of seed will naturally be required than with a seed of lower germination.

Treatment of Java indigo seed before sowing. The Java indigo seed has an exceedingly thick seed-coat, and unless properly treated before sowing it germinates very slowly and incompletely. The seed may either be scarified in a scarifying machine immediately before sowing or treated with sulphuric acid, as was originally suggested by Dr. E. J. Butler of Pusa in 1906. When Java indigo was first introduced into Bihar, one of the obstacles to its rapid adoption was the difficulty of obtaining a satisfactory germination after sowing. This difficulty was entirely overcome by the methods suggested.

The best method of treating the Java indigo seed is as follows :—

A maund of seed is placed in a wooden tub and 3—5 seers of strongest sulphuric acid, specific gravity 1·84, is added and thoroughly mixed in with the seed, so that every seed is wetted. For the sake of economy the minimum quantity of sulphuric acid should be used, and if the stirring is carefully done, the seed can be properly wetted with 3—4 seers of the strong acid. The 20 minutes should be counted from the time of first adding the acid and includes the 5 minutes necessary for a thorough mixing. With some soft-shelled seed, somewhat less than 20 minutes gives the best results.

At the end of the treatment, 20—30 gallons of water are rapidly added and the seed quickly stirred whilst the water is being poured in. Then leave for about half a minute for the seed to settle and pour off the washing water. This washing should be repeated at least five or six times, so that every trace of acid is removed. Finally the seed is drained as dry as possible and spread out on sheets to dry, in the sun if possible, turning over the seed frequently so as to facilitate rapid drying.

Weeding. Prior to sowing, the lands have to be kept scrupulously "clean" by constant weeding. During the early growth of the indigo, weeding is also frequently necessary, and it is desirable to harrow the fields to break up the hard-baked top soil and conserve the moisture during the hot weather. The harrowing obviates too a good deal of weeding.

Cutting. The Java plant is ready for a first cutting earlier than the Sumatrana, generally towards the end of May or early in June. The Sumatrana plant is not usually ready till a month or six weeks later. The exact time of cutting any particular field is regulated by practical considerations. The low-lying crops are first cut, because, with a more abundant supply of moisture, they have grown more luxuriantly, and because delay in cutting may lead to loss by flooding, either of the first or second crop. On some estates a large proportion of *khoontie* crops is frequently lost from flooding. There is little doubt that there is a steady increase in the indican content of the indigo plant during June and July, so that the crop should be cut as late as possible consistent with practical necessities. The plant is not only larger and yields more leaf, but the leaf is actually richer in indigo and gives higher produce per 100 maunds of plant. But if the plant is left too long before cutting it may begin to shed leaf, and so the actual yield will be diminished—this is especially the case in rich soils where the growth has been rapid.

The Sumatrana plant is usually not cut until the middle of July.

Between the first and second cuttings there is an interval of six weeks to two months. The first *mahai* may last, including

cuttings from both Java and Sumatrana plant, from say June 1st till early in August. Then after an interval of about a month a second *mahai* will follow, covering 20 to 30 days in September.

One of the great advantages of the Java plant has been that not only does it yield a heavy first crop, rich in indigo, but it is ready for cutting very early (frequently in April or early May), as compared with Sumatrana. A second cutting can therefore frequently be obtained in fields subject to early flooding, in which the ordinary Sumatrana *khoonties* would be entirely lost. The Java indigo is also remarkably resistant to slight immersion in water during the rains. Provided the crop is not entirely submerged, or that the water does not stand for too long a period, the Java crops receive little injury from an amount of water-logging which would in a very short time entirely destroy a Sumatrana crop.

Special methods of cultivation. A good deal of indigo is grown on low-lying lands in Bihar and Bengal, near river banks, on soil which is annually inundated and has a fresh layer of silt deposited on it. In such lands the indigo is sown broadcast after the river has subsided in October. Such cultivation usually gives a very good crop, but, as a rule, only a single cutting can be obtained as the rise of the river entirely covers the land. In the United Provinces where the soils are less retentive of moisture, Sumatrana indigo is grown on irrigation or is sown late after the rains have begun, when it gives a late first cutting in September. No second cutting is taken.

Manufacture.

Transport to factory. The plant is cut in the early morning and carried to the factory in carts drawn by two bullocks. It was formerly the custom in Bihar, and is frequently still so in the United Provinces, to cut the plant before daybreak. I have not been able to ascertain why the old custom in Bihar was abandoned. It is quite possible that the indigo plant may be richer in indican at night than in the day, and it certainly is an advantage to get the plant carried to the factory before the sun gets much power. There is no doubt that indigo which has to be brought from some distance

—frequently from six to eight miles—may undergo serious deterioration by exposure to the sun's heat. It then blackens or " burns " and the content of indigo in the leaf, as determined by analysis, shows a marked falling off. There is no doubt that prolonged exposure to the sun causes the liberation of the so-called *enzymes* in the leaf which act destructively on the indican—the parent principle of the indigo—so that it is clearly desirable to have the indigo cut as early as possible and brought to the factory in the early morning.

Loading the vats. Plate XV, fig. 1, shows the arrival of the bullock-carts charged with leaf at the vats. Fig. 2 in the same plate shows the loading of the leaf indigo into these. In Plate XVI, fig. 1, one of the vats has been filled with plant and the crossbars fastened down to prevent it from rising during the fermentation. Pieces of bamboo are placed across the vats below the crossbars for this purpose. These are shown in Plate XVI, fig. 2, resting on the edge of the vats.

Nature of the vats. The steeping vats are constructed of brick covered with Portland cement. Six or more vats form a range. The vats generally have a capacity of a little more than 1,000 cu. ft. with dimensions $18' \times 16' \times 3'$—$9''$ deep, the depth being measured to the cross beams. In some factories the vats are double-sized, that is with a capacity of 2,000 cu. ft.

Along the steeping vats, but at a slightly lower level, are the *beating vats*. (Plate XVI, fig. 2.) There is usually one large beating vat to six steeping vats. A wall 3 feet high runs down the centre of the beating vats, but a space is left at each end so as to ensure free circulation. The beating is now usually effected in Bihar by means of a wheel (wheel beating) driven by power. It is shown in the left hand upper corner of Plate XVI, fig. 2. This wheel has radial rods on which small flat paddles are fixed. As the wheel revolves the liquor is thrown up into the air as a fine spray, so that rapid oxidation can take place. The movement of the wheel causes a circulation of the liquor round and round the beating vat.

In many factories the beating vat has two partitions, and the wheel then works in the centre division.

Fig. 1. ARRIVAL OF INDIGO AT THE VATS.

Fig. 2. LOADING THE VATS.

Loading the vats. Former experiments by Bergtheil showed that the best results appear to be obtained in the case of the *Java plant* with a comparatively light loading, *viz.*, 75 to 90 maunds of plant per 1,000 cubic feet of vat-space. The Java plant contains far more indican than the old Sumatrana form, and if heavier loading is adopted a considerable proportion of the indigo remains unextracted and the efficiency falls off. On the other hand with Sumatrana plant, to work with a heavier charge is found to be more economical. The vat is usually charged with 110 to 120 maunds of plant.

Temperature of water and time of steeping. The steeping is generally carried out at a temperature in the neighbourhood of 90°F. From Bergtheil's experiments a scale of times of steeping was worked out according to the temperature of the water. The following gives the values :—

Times of steeping.

Temperature (in degrees, F.) ...	...	90°	93°	96°	99°	102°	105°
Period for Java plant ...	hours	12½	11½	10½	9½	8½	7½
Period for Sumatrana plant ...	hours	10½	9¾	9	8¼	7½	6¾

This works out to a decrease of 20 minutes steeping for every degree rise of temperature in the case of Java plant, and of 15 minutes in the case of Sumatrana plant. The temperatures given are the *averages* during the steeping period, that is, the mean between the temperature at the time of filling and that when the water is run off.

Plant cut before the break of the rains is generally richer in indican than the fresh growth following the rains. With such plant two hours extra steeping should be given at 90° F.

A temperature below 90°F. is considered unfavourable to a proper fermentation and should be avoided. Many of the Bihar factories are fitted with a steam pipe which runs along the *murree* or channel conveying water from the reservoir (*khajana*) to the steeping vats. This is shown in the foreground of Plate XVI, fig. 2. The steam is blown out from a number of perforations in the pipe

into the water as it flows along, and so raises its temperature to the necessary point. The temperature is measured by a thermometer as the water enters the steeping vat, and is maintained as nearly as possible at 90°F., which is generally adopted now as the standard temperature for steeping.

Changes in steeping. During the 10 to 12 hours period of steeping a fermentation occurs in the vats. This usually begins three or four hours after the plant is covered with water and is accompanied by a brisk evolution of gas—mainly nitrogen in the early stages, although later on considerable quantities of hydrogen and carbon dioxide are produced. This is not the place to discuss in full the mechanism of the changes occurring, but, briefly, the result is the transformation of the *indican*, the form in which the indigo occurs in the leaf, into indoxyl, which is dissolved in the steeping water and imparts to it the greenish fluorescence characteristic of the liquor when it is run out into the beating vat. The steeped plant—called *seet*—is removed from the vats and is used as a manure for the fields. Owing to its high content of nitrogen it is a very valuable manure for cereal and non-leguminous crops.

Beating. When the steeping is complete, the liquor is run off from the vats into the beaters. Six steeping vats are usually emptied as nearly as possible at the same time, and the whole lot of liquor beaten together. It is important *to ensure a good yield and a good quality of indigo that the liquor should be beaten immediately after it is run off* and not allowed to stand for even an hour. If left, a rapid series of decompositions occurs and the indoxyl is transformed into valueless substances other than indigo, which are carried down with the indigo during beating and give rise to a product of low purity (low indigotin content).

The beating is in practically all factories of Bihar effected by the *beating wheel* described above. It generally occupies about $1\frac{1}{2}$ hours, but in favourable circumstances may be complete in an hour. In some cases a longer time is necessary— two or three hours —but in general, when prolonged beating is necessary, the product is of a lower grade of purity, and loss of indigo occurs probably owing to bacterial and chemical decomposition of the indoxyl.

Fig. 1. THE VAT LOADED WITH PLANT AND FILLED WITH WATER.

Fig. 2. THE BEATING VATS.

The progress of the beating should always be carefully controlled by removing samples of the liquor from the vat and after allowing the precipitated indigo to settle, testing a little of the clear liquor by exposing a piece of absorbent paper (white blotting paper or filter paper), moistened with the liquor, to the fumes of ammonia gas. For this purpose the paper is held over the mouth of a bottle of ammonia. If the beating is incomplete, the blotting paper, where the ammonia comes in contact with it, becomes slightly blue or greenish in colour. The beating should be stopped *immediately* the test indicates that the whole of the indoxyl has been oxidized.

During the beating the soluble indoxyl is oxidized by the air to the blue pigment indigo. A layer of froth forms on the surface of the vat, sometimes two or more feet high. This froth has to be broken up by coolies who walk round and round the vats with a cloth stretched out between them. This is shown in Plate XVI, fig. 2. When nearing completion, the froth which is at first blue becomes more and more white and gradually disappears.

Settling the indigo. After beating the indigo "fecula" is allowed to subside. This usually takes two or three hours. A good subsidence is an indication of favourable working, and the more rapid as a rule the subsidence the better is the yield of indigo and the higher its purity. In rainy weather, the settling often takes place slowly and the indigo fails to subside in the form of a heavy fecula. In such cases the "seet water" which is run off contains finely divided indigo in suspension and is tinged green. When planters have a "green vat," subsequent operations become difficult and considerable losses of indigo occur.

After beating, the supernatant liquor—the "seet water"—is run off. In most factories, the vats are furnished with cut-off pipes, which revolve and can be adjusted to different levels. In others the running off is effected by opening a series of wooden plugs arranged down the side of the vat. The beating vat slopes down to one corner where the precipitated indigo or *mal* is collected. It is then passed through one or two strainers, and flows to a well or "mal jhari" from which it is raised by a pump or steam injector

to a large rectangular tank. The *mal* is again strained once or twice to remove sticks, dirt, and straw, on its way from the well to the boiling tank.

Boiling. The liquid containing the indigo (to the extent of about 0·5 per cent.) has to be heated to prevent fermentation which would cause loss of indigo, and to facilitate good filtration. The best practice is to boil it with very dilute sulphuric acid, which greatly improves the quality of the indigo by removing impurities, (*e.g.*, mineral phosphates, and the "indigo gluten" which is soluble in dilute acid). The best method of doing this is as follows :—The *mal* is heated to about 160°F., immediately after lifting, in large rectangular iron tanks, by blowing steam directly through the *mal.* The *mal* is then allowed to settle, and the clear liquid above the sediment gradually run off by removing pegs, one after the other, from holes perforated in regular order in the side of the iron tank.

After the first heating, as large a volume of fresh water is added as is conveniently possible. Steam is now turned on and the necessary quantity of sulphuric acid added. In general about 4 to 6 lb. of strong sulphuric acid should be used for the *mal*, corresponding with 1,000 cubic feet of steeping-vat space. The acid is diluted with about 10 times its volume of water in a tub placed above the boiler and fitted with a long handled plug. Care must of course be taken in diluting the acid to add the acid to the water and not *vice versa.* After adding the acid, the temperature is again raised by steam, *this time to about* 160°*F.*, the indigo again allowed to settle, and the water again cut off. Finally, water is added and the temperature raised nearly to the boiling point (200° to 210°F.), the *mal* is again settled, and the clear liquor cut off, when the *mal* is ready to run off to the filtering "tables."

The heating to 160°F. with acid instead of boiling directly has been found in practice to give the best results. If the *mal* is heated to 212°F. with acid straight off, troublesome frothing occurs and the grain of the indigo is broken up, so that a very finely divided and badly settling indigo is obtained, which also filters very slowly.

The above process of purification will convert an indigo testing 60 per cent. indigotin into one which contains 65 to 70 per cent.

Fig. 1. FILTERI..G AND PRESSING INDIGO.

Fig. 2. FILTER AND PRESS HOUSE.

of indigotin on the dry substance. With low grades of indigo (50 to 60 per cent.), a larger quantity of sulphuric acid is necessary than with higher qualities (60 to 65 per cent.), in order to remove the impurities.

Filtering the indigo. After boiling, the *mal* is run on to the filtering tables shown in Plate XVII, fig. 1. Usually these are about 18 feet long by 7 feet wide. They are made of light battens fixed on a stout wooden frame with sides about 18 inches high and sloping as shown in the photograph. Across the table is stretched the stout cotton cloth specially made for the purpose, which is used to retain the indigo. The table stands in a shallow trough of cement, which is surrounded by a drain to carry off the filtrate. When the thin *mal* is first put on the cloth, the filtrate runs through blue, and such runnings are pumped back on to the cloth and refiltered. Finally, the filtrate becomes perfectly clear. If the early operations have been favourable, the clear liquor is of a light sherry colour. Much of the liquid is allowed to filter through the cloth, but to save time a large proportion is removed, as settling proceeds, by gradually lowering the cloth at one corner, so as to "cut off" the rest. The paste is then scraped down to one end of the frame and the cloth folded over to squeeze out as much liquor as possible. After draining in this way the pulpy mass (thick *mal*, containing from 8 to 10 per cent. of indigotin) is carried to the presses in wooden boxes.

Pressing. The presses are shown in Plate XVII, fig. 1. Each consists of a rectangular box, the framework having on all sides numerous perforations. The box is fitted with two thicknesses of strong, closely woven cloth into which the thick *mal* is packed. Pressure is applied by means of screws, working on to heavy cross beams. The screws are turned by means of heavy nuts rotated by long levers; six or more coolies operate this as shown in the photograph.

The boxes are usually built in two sections, each 6 inches deep. They are filled with the paste until the indigo has a depth of 12″ to 13″ at the beginning of pressing. When filled, a perforated wooden cover is put on and pressure *gradually* applied so as to

squeeze out water. The pressing takes several hours and is complete when the indigo has been pressed into a slab about 3″ to 3¼″ thick. After pressing the moist cake is cut into smaller cakes of about 3″ side, and each cake is stamped with the factory mark and the number of the day's boiling. They are then taken to the drying house. Plate XVII, fig. 2 shows the exterior of a presshouse of a small factory.

Drying. The drying-house is a lofty building containing a number of *machans* or frames fitted with shelves of light bamboos or wire netting. On these shelves the cakes are left to dry for several months before they are ready for the market. The drying is usually a slow operation, because the manufacture of indigo is largely carried out in the rains when the air is exceedingly humid. During the drying considerable bacterial fermentation occurs and ammonia gas is evolved. Mould grows abundantly and frequently forms a hairy mass, ½″ to 1″ in thickness, on the surface of the cakes. Although decomposition occurs in the indigo cakes during drying, there is considerable evidence to show, as pointed out originally by Rawson, that it is only the impurities of the indigo which are destroyed and not the indigotin, so that there is no loss of really valuable material. On the other hand a slight purification actually takes place owing to the destruction of the impurities, and the cakes actually become richer in indigotin. From time to time during drying the cakes are brushed, and when quite dry (in November or December) are packed into chests of well seasoned mango wood, each chest containing about 4 maunds of indigo.

Rapid working essential. In order to prevent unfavourable changes from occurring during the earlier stages, every effort is made to carry these through as rapidly as possible. The plant is brought to the factory with the minimum of delay, the loading is expedited by utilizing a full staff of coolies, and arrangements made to start the steeping of a whole range at nearly the same time. This is a point of great importance. If the vats are loaded at different times the steeping in the different vats will be finished at different hours. The liquor from the early vats would then have to be run out and wait in the beating vat to be beaten until the later vats

were ready. During such waits, decomposition occurs and undesirable organisms probably multiply, which have an injurious effect on the liquor subsequently to be beaten. Some of the most successful planters have informed me that starting the steeping in a whole range simultaneously, so as to run off the whole lot of liquor at once, makes a very great difference in the quality of the indigo and ease of working.

The vats are usually fully loaded and the steeping started by about noon. The steeping is therefore completed by midnight, when beating is immediately proceeded with, this operation in most cases being carried out at night. After settling, the liquor is ready to run off by daybreak, when the rest of the operations are carried through as speedily as possible.

Having described the existing methods of manufacture of indigo in Bihar, it is possible to consider how far they fall short of perfection and how they can be improved.

[I must express my indebtedness to Mr. W. Finch of Dholi Factory for kindly making arrangements for obtaining the photographs of Birauli out-works printed with this article. At this out-work the beating was carried out in the daytime instead of at midnight as is usually the custom now in Bihar, so that it was possible to obtain a photograph of this operation.]

(*To be continued.*)

THE CONSOLIDATION OF AGRICULTURAL HOLDINGS IN THE UNITED PROVINCES.

BY

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I. THEORETICAL INTRODUCTION.

IN a paper on the Capitalistic Development of Agriculture which I prepared for the meeting of the Industrial Conference at Bombay in December 1915, will be found set forth the theoretical considerations which prove unquestionably that the road for India's material advancement is through the increase of the productivity of agriculture. The present paper is an attempt to outline, so far as relates to the United Provinces, one of the most important practical steps which are necessary in order to realize a capitalistic development of agriculture. Needless to say, the investigations of numerous agricultural experts extending over many years have given us a vast and most valuable body of knowledge as to soils, crops, manures, and methods of cultivation. The difficulty now is not so much to make further scientific and technical discoveries as to make use of those we have. The huge agricultural population seems to be obsessed by a most obstinate inertia, so that the numerous efforts converging on it from without have no appreciable result. Agricultural instruction is offered, co-operation is fostered, selected seed is distributed ; but very many thousands who know of these offers of aid will not, or cannot, avail themselves of them. There would appear to be a moral apathy ; an appalling absence of ambition ; a fatalistic acceptance by the cultivator of his present limited means of subsistence and low standard of living.

My own observations do not altogether support this view. Speaking of the younger generation of ryots whose habits of thought are not entirely fixed, I believe the cultivator is as keen to improve his position, and to adopt any means within his reach which he believes will attain that end, as anyone in India. Ambition is soon crushed out of him, however, by the appalling dead-weight of physical, legal, and social conditions which he cannot change. His local obligations are extraordinarily onerous. There are stringent family obligations, besides those directly connected with his occupation. He is not a free man, as we understand personal freedom in England. In recent decades he has been further hampered by the growth of population, causing competition for land, so that rents have risen considerably in zemindari tracts, and the cultivator there has got little advantage from the rise of prices of agricultural produce.

It is an economic law of the very first importance that the earnings of any class, whether wage-earners or independent workers, like the cultivators, tend to conform to their standard of living which it is usually, though not always, more difficult to change, either upwards or downwards, than the average money income of the class. The standard of living is raised chiefly by two agencies : education and travel. A rise of the standard of living without the expansion of the means of gratifying it produces discontent almost as severe as a sudden fall of real earnings (*i.e.*, income relatively to retail prices). When the standard of living remains unchanged an increase of earnings without a corresponding increase of the standard of living simply reduces the amount of work done by the people in question. They become lazy and apathetic, and lose those sturdy and manly qualities which are produced by a wrestle with Nature which is hard but not hopeless.

In undertaking any great reform in agriculture, it has, therefore, to be borne in mind that the tendency will be for the beneficial possibilities in increased income to be whittled away—(1) in ryotwari tracts and the Punjab colonies by a growth of apathy and idleness ; (2) in zemindari tracts by increase of rentals (only slightly retarded where occupancy rights prevail) ; (3) in tracts of both

tenures by an increase of population and diminution of size of holdings.

In the absence of any great catastrophe such as famine, plague, or war, the standard of living alters slowly. It appears also to be true that the more educated a population is and the higher its present standard of living, the faster will a further rise take place and the greater will be the resistance to a fall of the standard of living. In England a new standard of living becomes fixed after persisting for only three or four years. In India probably prosperity must continue longer for the habits of life to become changed and adapt themselves to a higher scale of living and for this in its turn to become a habit.

It is not to be supposed, however, that the standard of living is, so to speak, the independent variable, to which the rate of earnings will sooner or later conform. There is here, as in almost every economic quantity, a case of action and reaction. The resultant is an equilibrium between the opposing forces, which forces are, however, themselves continually in a state of flux, more or less. The rate of earnings in any employment at any moment may be regarded as the resultant of an equilibrium between the standard of living and the marginal productivity of labour, the latter determining the demand for labour in that employment, the former determining the supply. The problem before us, therefore, is to increase the marginal productivity of labour in agriculture and at the same time to raise the standard of living of the cultivating classes, including labourers, so that they will feel it worth their while to supply additional labour by working a larger percentage of their time or with greater energy.

Once a higher standard of living has been established, the economic forces of degeneration, such as growth of population, which tend to rob the cultivator of the net produce of his additional exertion, encounter a very strong force of opposition. Persons having a high standard of living will go out of the cultivating business rather than suffer a considerable diminution of their standard of living; and they can do this by migrating to the towns where industries are springing up.

Whilst the standard of living and the marginal productivity of labour are at any moment in a state of equilibrium with one another, or are tending towards it, we must note that any change in the one has an effect in the future on the other. For example, a lower marginal productivity of labour will mean lower earnings and the possibility of maintaining only a lower standard of living. Result : the workers, after some unrest, gradually become accustomed to this low standard of living, and it tends to become fixed. Again, any higher standard of living means increased efficiency, for work is done more intelligently and for longer hours. This enables a more advanced organization of production to be undertaken ; this raises the marginal productivity of labour, which in its turn provides increased earnings, and a margin permitting the standard of living to rise still further.

There is thus a reciprocal effect of the rate of earnings and standard of living upon one another. This effect is often slow in acting, the necessary adjustments taking place in a few years—3, 5, 10, or 15 according to circumstances. On the side of the demand for labour the marginal productivity is determined at any time by the actual physical conditions of the instruments of production and by the state of business organization and the demand for the commodity produced, the latter, in the case of staple commodities, being measured by their prices in the large markets. In the manufacturing industries the instruments of production are constantly changing through the invention of new machinery, the building of new factories, and so forth. In agriculture, however, there is a peculiar fixity of the instruments of production apparently due to the special part played by land and the natural agents in all agricultural production and to its immobility. It is a peculiar and most important sociological fact that the laws and customs regulating ownership and use of land have a stronger tendency to persist than any other characteristic of society. The sentimental attachment of the people to the land, the importance of land as family property in all countries until the industrial revolution has been passed through, together with the inertia arising from long-formed habits, all contribute to making both the physical and legal conditions of

land tenure extremely persistent and difficult to alter by any extraneous action other than the *force majeure* of the law.

It is important for us to note that the physical condition of the land as regards not only its fertility, but its division into fields, as well as the legal conditions of tenure, have a decisive influence on the marginal productivity of labour in agriculture, and consequently indirectly upon the standard of living. The only change in physical condition which, in the present constitution of Indian society, is not resisted, is the subdivision of the agricultural holdings in ownership which arises from the prevailing laws of inheritance, both Hindu and Mahomedan. It would appear that this subdivision of holdings has been a sufficiently slow and gradual process in certain districts to allow the resulting decrease of the marginal productivity of labour to bring down the standard of living with it, perhaps almost to the same extent. I cannot cite any definite proof of the decline of the standard of living, but am inclined to think that it has taken place in certain districts where security of life and property was well established whilst the population was still sparse. Certainly there is a danger of the fairly high standard of living which is being created in some parts of the Punjab canal colonies slowly degenerating unless the two agents for raising the standard of living —education and travel—are vigorously applied.

From the foregoing considerations a conclusion of the highest importance follows. The inertia of the land tenure and customs causes the standard of living to become fixed at a level corresponding with the physical condition of the land. The consolidation of scattered holdings by re-stripping will create a new physical condition, and allow greater efficiency of agricultural methods, and thus a higher marginal productivity of labour and a higher standard of living. The mere rearrangement of fields into compact holdings will not, however, affect the average size of the holdings ; and it will not, of itself, do much to prevent the continuance of the process which is mainly responsible for the present condition of holdings. These will continue to degenerate by further subdivisions, although remaining homogeneous at first ; and the degeneration will be so slow that it will carry the standard of living down with it.

It would appear extremely unlikely that any external regulation can prevent the growth of population producing a further subdivision of the unit of cultivation which is the important aspect of the question. Further subdivision of ownership might be prevented by refusing perfect partition so as to produce any field or group of contiguous fields less than six acres in area. Enforcement of any law of primogeniture would be impossible; but a system of officially recognized trustees of estates imperfectly parted might possibly be devised.

This, however, would not really affect the question of the size of the unit of cultivation which is all-important from the point of view of improved agriculture; and so long as the ryot is content to cultivate a holding of less than 10 acres in area as his principal or only source of livelihood, so long will he do it in spite of any laws to the contrary, and lettings to tenants, occupancy and non-occupancy, will be made on that basis.

The only remedy for the evil tendency to a reduction of the average size of the unit of cultivation is by raising the standard of living so that people will refuse to cultivate small holdings and will seek occupations elsewhere rather than do so. This postulates the existence of openings in occupations elsewhere and these are undoubtedly arising in industries, and could be made available by the opening of waste lands for settlement in the Central Provinces, Assam, Punjab, and certain Native States. If the importance of such emigration were realized it could be properly organized. But unless migration is assisted and so comes to be regarded as a lesser evil than the lowering of the standard of living, we shall have renewed reduction of the size of the holdings cultivated.

I have already stated that the higher the standard of living becomes raised amongst a population the more tenaciously do the people cling to it. If the standard of living be raised but a little it may easily deteriorate; if it be raised to a considerably higher level there will be a far more than proportionate increase of the resistance to the economic forces tending to lower the standard of living.

The conclusion which I think is justified from the foregoing considerations is that the only way to effect a permanent increase of the standard of living is to raise it at one stroke—that is to say within a very few years—by reorganization of holdings so as not only to consolidate them but also greatly to increase the average size. It would be necessary, of course, that all remedial measures should be put into operation at once—the re-stripping of holdings; re-grouping so as to produce a larger average holding, with the concomitant removal of the surplus population; accompanied by definite demonstrations of improved agricultural methods on the reorganized village holdings, and the compulsory education of all children with a view to raising the standard of living. Improved communications designed to bring a metalled road to every *abadi* would be a necessary part of this reorganization of rural life. I wish to record my opinion that it is almost useless to undertake these measures piecemeal. The forces of degeneration are so strong with the existence of a low standard of living that each measure of reform would be successively defeated. Far better results would be obtained by making a combination of agricultural and educational reforms in one district at a time, maintaining the special measures of education for a sufficiently long period of time for a new and considerably higher standard of living to become fixed as a habit amongst a population.

Such a plan as I have outlined postulates a very considerable expenditure of public money in any district which should thus be put under a reorganization. There cannot be any question, however, in my own mind that this expenditure will be amply justified and repaid by the results that will be obtained. With larger holdings cultivated by machinery co-operatively owned, the produce per acre would be increased by 50 to 100 per cent. in different lands. The net social income after providing for the subsistence of the agricultural population at the higher standard of living supposed, would be sufficient to support a very much higher taxation. The question of the manner of collecting additional revenue is of no importance. It could certainly be collected because there would be so much more income from which it could be paid.

The district would, therefore, be more than self-supporting after the first few years, and could not only pay the interest upon any loan that might have been contracted for making roads or other works, but could also contribute proportionately a greater share than formerly to the general revenue of the province, thus making equitable repayment of the special expenditure which had been lavished on it in the early years of the reorganization. For a fuller discussion of the growth of social income from public works I would refer the reader to an article on The Art of Economic Development recently published by me in the *Indian Journal of Economics*.*

So far as I am aware the relevant economic principles have been sufficiently considered in the foregoing introduction. I have stated them in terms of the zemindari system of land tenure; but the statement would differ in no essential feature when applied to ryotwari tenure, for the State may here be regarded as the landlord, but one of a benevolent disposition, in most places refraining from taking a full economic rent. The reorganization will be more beneficial in the ryotwari than in the zemindari districts provided the standard of living is sufficiently raised; but its benefits will be more transitory if the standard of living is not sufficiently raised because the larger margin of profit to the cultivator will merely enable population to increase faster and the subdivision of holdings to proceed so much the faster.

The principles which I have stated are in fact independent of law, being based upon the primary economic instincts of mankind. I do not think it necessary to discuss the legal aspect of such a reorganization because it appears to me that this is one of those fundamental reforms in which all existing law must be swept aside, the resettlement being based upon common principles of expediency and justice. Although it may be held that there are certain family rights of property in land, the loss of which can never be compensated fully by any money payment which would be within the financial possibilities of any scheme of reorganization, yet I am convinced that the State must adopt the policy that rights which cannot be

* Vol. II, Part 1, p. 52.

more satisfactorily adjusted by other means, as by the allotment of land in the reorganized village, or in some distant locality, must be compromised by a money payment. In the reorganization all rights whatever must first be liquefied and then a re-allotment of existing land should be made upon the basis most expedient for the community as a whole after the type of the new community to be created has been decided. The remaining rights would then be dealt with serially in such manner as to give the most benefit, or do the least harm, to the persons concerned. It would be dangerous to attempt to regulate any such reorganization by precedent, or to make it conform with the existing laws which have totally divergent aims, being mainly concerned with the maintenance of the *status quo*. Such a fundamental change can only be carried through successfully by reliance upon first principles, having constantly in view the welfare of the new community to be created and applying the broad principles of humanity to the cases of hardship which may be expected to present themselves.

(*To be continued.*)

THE TENTH MEETING OF THE BOARD OF AGRICULTURE IN INDIA.

The tenth meeting of the Board of Agriculture was held at Poona from 10th to 15th December, 1917, under the presidency of Mr. James Mackenna, Agricultural Adviser to the Government of India. The meeting was a notable one from many points of view. This was the first occasion on which the Board enjoyed the honour of being presided over on its opening day by the Governnor of a Presidency, a Governor who in spite of his other onerous duties is still a practical farmer and was an agriculturalist before he was a Governor. It is to be hoped that in future when meetings are held in alternate years at centres other than Pusa, His Excellency Lord Willingdon's example will be followed not merely from a sense of duty or recognition of the growing importance of the Board but from a genuine interest in agriculture such as His Excellency displays. The subjects on the agenda were wide enough to appeal to not only the agricultural, but also the economic and industrial, interests. The number of those who took part in the discussion was the largest on record. The members (48 in number) were as usual drawn from the various Agricultural and Veterinary Departments. The visitors included, besides the Hon'ble Sir Claude Hill and the Hon'ble Mr. R. A. Mant, the Inspector-General of Irrigation, the Officiating Director of Army Veterinary Services, a University Professor of Economics, an Assistant Director of Public Instruction, a Registrar of Co-operative Societies, representatives of the cotton trade of Bombay and of firms interested in agricultural machinery and fertilizers. But the most noteworthy feature was that several non-official members of the Provincial Legislative Council were invited as visitors and they took an active part in the discussion and materially widened the lines of the debate.

As mentioned above, the first day's proceedings opened with a speech by His Excellency Lord Willingdon, which was characterized by an insight into the practical side of agriculture which was much to the point. His Excellency, after paying a tribute to the worth and work of the Agricultural Service, referred to his own personal experience in this country as a breeder of pedigree stock, so well known to the readers of this *Journal*, and invited those who were interested in dairying to inspect his herd and milk records at Ganeshkhind. Not a few availed themselves of the excellent opportunity so kindly offered by His Excellency of witnessing a practical demonstration of the results of scientific breeding and scientific feeding. In conclusion, His Excellency acknowledged in fitting terms the zeal and energy with which the Bombay Department of Agriculture has created a desire among the farming classes for improvement and progress.

Sir Claude Hill, Member in charge of the Revenue and Agriculture Department, Government of India, next addressing the meeting, echoed the sentiments of all present when he warmly thanked His Excellency Lord Willingdon for having honoured the Board by his presence on that day. He referred to the death of Professor Barnes in suitable terms and the loss occasioned to the Department by his premature decease. Sir Claude then dealt in detail with the various subjects set down for discussion by the Board and pointed out how the Agricultural Department could co-operate with the Military in the establishment of horse-breeding farms in different districts in India.

Time and space do not allow of full justice being done to the seventeen subjects discussed and the fifteen resolutions passed by the Board. For this the reader is referred to the published proceedings of the Board.* All that can be done here is to touch on a few salient points in the discussions that took place onthe various subjects.

The first item on the agenda evoked considerable interest both on the part of officials and the large number of non-officials who were present, as it dealt with the disability of agriculture over a

* *Proceedings of the Tenth Meeting of the Board of Agriculture in India*, 1917. (Supdt., Govt. Printing, India, Calcutta.)

large part of India arising from the fact that the size and distribution of the land holdings are such as to render them essentially uneconomic units. Here the Board was dealing with a problem of the widest interest to India and the subsequent debate dealt with all sides of the question from legal to agricultural. The Hon'ble Mr. Keatinge who opened the discussion showed in an interesting speech how this sub-division of land smothers any attempt at agricultural improvement almost at its birth. The root cause of this trouble lies in the existing law of inheritance, both Hindu and Mahomedan, which provides for the partition of a holding, however small, amongst the members of the family, and for the repartition of the sub-divisions so created at each generation and so on *ad infinitum*. The Hon'ble Mr. Keatinge was therefore in favour of starting with a permissive Act allowing any man to declare a holding indivisible for ever in spite of the existing law of inheritance, and then such a holding should descend by primogeniture. This, being the policy of least resistance beloved of all governments, brought forward some pointed suggestions from Indian members for more drastic action. The Hon'ble Dewan Bahadur Godbole who had once raised this question in the local Legislative Council was for compulsory consolidation of all holdings and then legislative prohibition of any re-division. Professor Stanley Jevons who spoke from the point of view of the economist advocated prevention of reduction of the average size of the unit of cultivation by raising the standard of living and reorganization of holdings so as not only to consolidate them but also to make them larger. He was for action on the lines as drastic as the "enclosure" movement of England, but with the consent of the majority of the owners of the holdings. Referring to the United Provinces which is not a ryotwari tract like Bombay but a zemindari province, the Hon'ble Mr. Hailey said that a change in the revenue law rather than in the law of succession would meet the needs of his province. The Director of Agriculture, Madras, relied more upon the awakening among the people themselves than on any legislation. He feared Mr. Keatinge's permissive legislation would have little effect unless accompanied by a campaign of enlightenment. Several other gentlemen took part in the

discussion and there was unanimity on the point that this crying evil should be put down. Sir Claude Hill who summed up the discussion believed that no good would come from riding roughshod over the traditional sentiments of a people not radically progressive, and the first step should be to give them an opportunity of showing how far they were prepared to take remedial measures on a permissive basis. That seemed to him the true merit of the compromise embodied in Mr. Keatinge's bill. If the benefits expected from the permissive measures were found to be illusory, it would be for consideration whether more drastic legislation on the lines proposed by the Hon'ble Mr. Godbole should not be resorted to. The resolution adopted by the Board on the motion of Dr. Mann recommended that the question be closely investigated and experiments made in each provincial area in consultation with the Registrar of Co-operative Societies with a view to the adoption of such measures as seem best adapted to meet the special local requirements and the introduction of such legislation as may be necessary.

Subjects II & III referred to the programmes of the Imperial Department of Agriculture and the Bacteriological Laboratory at Muktesar and of the Provincial and Native States' Agricultural and Veterinary Departments, and the absence of any debate showed conclusively that the Board was neither critical nor anxious for enlightenment on the subject of programmes. No criticisms or suggestions were forthcoming and the question arose as to the necessity of submitting these programmes to the Board. The view of the majority seemed that the programmes were in a way useful, but it was not necessary to submit them to the Board. It was therefore recommended that they should only be published annually as a separate compilation for circulation to all concerned.

The next two subjects (*IV & V*) dealt with the publications of the Department. It is pretty generally recognized that the Indian Agricultural Department has not got the full credit in the past for all the work it has done, partly because of the inadequate methods of publication then in vogue, but mostly because of the apathy with which agricultural problems are regarded by the public press in this country and the peculiar views taken in the few critical

articles which have appeared from time to time. Recently attempts have been made to popularize the departmental publications and make them more attractive, and the discussion on the subject elicited the fact that the *Agricultural Journal of India* was at least regarded as being of popular interest in its new form. With regard to the question of summarizing and indexing agricultural publications, the necessity for such work was widely recognized, but it was felt that there was no staff to undertake it. The Board recommended that the reports of agricultural stations in India should be summarized and indexed by the Imperial Staff at Pusa which will be strengthened for the purpose.

The question of holding sectional meetings of the Board of Agriculture in years in which a meeting of the full Board is not held (*Subject VI*) was then discussed and the Board recommended that meetings of the mycological, entomological, and chemical sections should be held in years in which there is no meeting of the Board, that these should not be confined to members of the Agricultural Departments but others interested in these subjects be invited to attend, that agricultural officers engaged in experimental work should also hold periodical sectional meetings to discuss their results and methods, and that the veterinary section should meet every three years. As regards the botanical section the Board did not think any sectional meeting necessary, for most of the officers are engaged in investigations on special crops or groups of crops, and it was felt that there would be little advantage in a botanist engaged in work on cotton and wheat meeting others working on rice and jute. The Board, however, expressed an opinion that members of the Department might with advantage arrange to see the work carried on by others engaged in the same branch of work in other provinces.

The problem how to deal with the short-sighted and evil practice of mixing and adulteration which is slowly bringing Indian produce into disrepute in foreign markets and robs the cultivator of the full share of his profits, has come more prominently to notice as the result of the war. As has been stated by the Government of India in a reference which has been made to all Chambers of Commerce,

it seems reasonable to suppose that the present war will be followed by a period of keen competition among industrial nations for materials of all descriptions and for products which India should be in a specially favourable position to supply, and when it is realized that the watering of cotton, the adulteration of jute, and the general monkeying of all other agricultural produce put forward for export in India has reached a fine art it seems hardly probable that an era of high prices or a reputation for commercial morality will automatically follow. No formal resolution was passed by the Board on this subject (*Subject VII*), but the report of the committee was adopted. The committee regarded the co-operative machinery as too slow for the changed conditions created by the war, and also brushed aside the proposed remedy of issue of certificates of purity either by Government or commercial bodies as cumbrous and expensive. In their view the most hopeful method would be that of control at the port of export and the refusal to allow the export of produce below a minimum standard of cleanliness or of purity, such a standard to be fixed by or in consultation with representatives of the trade both in this country and the countries to which the bulk of the produce is exported. Such a standard would of course vary with every class of commodities and for the same class would change from time to time. The committee also suggested that in order to defray the costs of examination at the ports an export duty should be levied. Once it is widely realized that traffic in adulterated produce is no longer a paying proposition, the trade will adjust itself to the requirements of the consumer.

So long as the bullock remains the chief motive power of the plough, the Veterinary Department and the Agricultural Department must follow each other about India and the development of veterinary science in India is therefore closely bound up with the progress of agriculture. Thus the subject of veterinary education (*Subject VIII*) was from this point of view no less important than that of agricultural education itself. The principal question before the Board was whether it was advisable and possible to raise the standard at one or more selected colleges so as to turn out students who will be qualified for appointment to the higher grades of the

Provincial Service or ultimately to the Imperial Service and to make recommendations as to the best method of reorganizing and administering veterinary colleges and schools. A committee mainly composed of veterinary experts dealt with the question and the Board adopted their report without discussion.

The next subject (*IX*) was that of the value of phosphatic manures in India and the possibility of arranging for the manufacture of superphosphates on a larger scale locally so as to lessen their cost. Though at present there is not sufficient evidence to state definitely that any deterioration of the soil arising from depletion of phosphates has occurred generally throughout India, the importance of phosphatic manures to the various crops has been widely demonstrated by the experiments carried out at Government farms in the different provinces and it was felt that a demand for this manure would come. The Board therefore recommended that a survey of the country's resources in mineral phosphates should be undertaken, that with a view to keep the supply at a price within the reach of the cultivator the control over all the internal mineral sources of supply should be retained by Government, and that the question of reducing internal railway rates charged on concentrated manures should be considered by the Railway Board.

It is generally recognized that the large number of field experiments carried out in the past have not led to such definite results as were anticipated and this caused the subject of experimental error (*Subject X*) to be discussed this year. In a country like India nothing is likely to do more harm to a young department than hasty conclusions and generalizations. Great importance therefore attaches to the comprehensive recommendations made by the Board on this subject.

As regards the proposed collation and publication, for general information, of the useful data on manuring and tillage now available as the result of the experimental and research work already carried out (*Subject XI*) the shortage of staff now so evident in the Department rendered it impossible for any action to be recommended by the Board.

The next subject (XII) of bringing improved methods of agriculture to the notice of cultivators may truly rank as the "popular doyen" of the Department, and though it had remained in retirement for the last four years with a view to recruiting its strength yet even the versatile Dr. Mann who has fathered it from the beginning was forced to admit that the subject has not increased in weight since it was last seen at Coimbatore in 1913. No important new method had been evolved since then and the Board satisfied itself with making recommendations as regards the extension of the methods at present in vogue only in certain areas. The Board recommended that where district boards employ district agricultural inspectors to tour villages, advising on seed selection, tillage, prices, etc., they should be members of the subordinate staff of the local Agricultural Department deputed for the purpose and should work under the direction and supervision of the Agricultural Department; that co-operative organizations should be widely utilized for demonstration purposes and where these do not exist steps should be taken to create them; that *taccavi* loans for agricultural purposes and improvements should be granted on the recommendation of the officers of the Agricultural Department; and that the system of appointing trained cultivators, such as the *Kamdars* employed in the Central Provinces and other provinces, as local demonstrators of agricultural improvements, should be widely extended.

The necessity for legislation regarding the sale of fertilizers (*Subject XIII*) was next taken up. It was considered by the Board in 1906 and again in 1907 and the conclusion then arrived at was that the time was not ripe for the introduction of legislation, but the desirability of maintaining a special watch over the development which might take place in their use was recognized. The use of artificial manures has spread considerably in this country during the last decade and the planter as well as the ryot requires protection against adulteration. The Board therefore considered that the time has now arrived for the introduction of legislation to regulate the sale of fertilizers

Subject XIV aroused a good deal of interest owing to the fact that a world's food shortage is at present being experienced and

though the primary function of the Agricultural Department is the increase of yield yet the necessity of accelerating the pace of increased production is evident to all. That the shortage will continue for a long time even if peace is restored soon is now almost a certainty, and that India can take a large share in relieving this shortage cannot be denied. It was recognized that the bringing of waste areas under cultivation or increasing the area under foodstuffs are administrative questions. The methods which come properly within the scope of the Agricultural Department are the introduction of improved varieties, manures, and better cultivation, and the Board showed itself fully alive to the question before it.

Though the problem of putting the cane sugar industry on a sound basis (*Subject XV*) has been discussed at each meeting of the Board since the year 1911, it has assumed since the beginning of the war an interest of its own as the prevailing high price of sugar has given India an opportunity to considerably improve her position in this industry. The Board of 1917 was notable for a definite step in this direction being advocated in the creation of a sugar bureau. It also recommended the opening of a sugar station in Bihar and also in Assam and the extension of experimental work on the subject in Burma. Some of the facts given by Dr. Barber in his comprehensive review of the situation showed clearly how the question of a bureau has become one of immediate urgency. While the Department is continuing work on the introduction of the new varieties of cane, of better agricultural methods, and of improved manufacturing processes, the need for a central authority to correlate all the accumulated facts for the benefit of future workers has become acute and in our opinion the Board could have gone further and advocated the creation of a committee to tackle the whole subject of the industry at this the most favourable opportunity possible. Dr. Barber's claim that the problem of producing the seedlings suitable for North Indian conditions, under which the largest area under sugarcane lies, is in a fair way to being solved was borne out by the series of seedlings which were exhibited in the Board's room. It is easy to realize the immense importance of this

success, if it fully materializes, in the development of a really healthy sugar industry in this country.

The necessity for investigation into the water requirements of crops (*Subject XVI*) followed. When we take into consideration the large area under irrigation at present and its extension in the near future, the importance of the investigation as to how the water can be used to the greatest advantage and with the least possible damage to the soil will at once be apparent. Dr. Leather on the chemical and Mr. Howard on the agricultural side have both gone into the subject, while agricultural and irrigation officers in the provinces have made some important observations; but all this scattered information needs to be put together and further investigations are necessary. The Board therefore resolved that a special Imperial officer of agricultural experience with a suitable staff be appointed to investigate the water requirements of crops and that an experimental station or stations be selected for this research work by the staff after it has been appointed.

The last day of the Board's sitting was devoted to agricultural education (*Subject XVII*) and this let loose a flood of eloquence which had been pent up by the technicality of the previous subjects. Never was it more clearly shown that every one has an opinion on education and the Board was very emphatic in the expression of its views. "A sound system of rural education based on rural needs is essential," "the present system is wholly inadequate," "revolutionary improvements are needed in the system of rural education," "there should be co-operation between the Education Department and the Agricultural Department in effecting necessary changes," "the provision of the necessary funds should form the subject of an immediate, careful, and detailed examination by the various provincial administrations," are some of the phrases occurring in the resolutions. A couple of clever speeches by Mr. Biss, the educational expert detailed to shepherd the committee, did much to bring home to the Board the lines on which he thought the soundest progress could be made. With Mr. Higginbottom advocating the fulfilment of everything in the next five minutes, Mr. Clouston in favour of slowness because it was slow, Dr. Kunjan Pillai asking

for the millennium based on the present system of education while Dr. Coleman demanded a thorough overhaul of the foundations, the Board listened to a debate of a class rarely heard before. One cannot help thinking that possibly the choice of the Council Hall had much to do with this unwonted eloquence which formed a fitting termination to the most successful meeting of the Board yet held. It was sad to feel that the familiar faces of Col. Pease, Dr. Barber, and Mr. Gammie would be missing from the next meeting, and the President in bidding them farewell expressed the feelings of all. The opportunities for seeing the Agricultural College, the adjacent farms, and the work of the Bombay Department in and around Poona, the arrangements for the meeting, the camp and the mess at the Gymkhana Club, coupled with the general amenities of the station, made the 1917 meeting a very pleasant one to all concerned.

IN MEMORIAM.

Lieut. E. J. Woodhouse, M.A., F.L.S.

It is with deep regret that we record the death of Mr. E. J. Woodhouse, late Principal of the Sabour Agricultural College and Economic Botanist to the Government of Bihar and Orissa.

Mr. Woodhouse was educated at Marlborough and Trinity College, Cambridge, and joined the Indian Agricultural Service in 1907 as an Economic Botanist. In 1911 he was appointed Principal of the Sabour Agricultural College and held that post till in 1915 in response to the call of duty he joined the Indian Army Reserve of Officers.

He has now made the supreme sacrifice, having died of wounds received in action on the 18th December, 1917. *Dulce et decorum est pro patriâ mori.*

As a member of the Department Mr. Woodhouse was a Botanist of very high abilities and with much enthusiasm for his work. Amidst the heavy duties of organizing the Sabour College he found time to do a considerable amount of botanical and entomological work of real and lasting value. Personally Mr. Woodhouse had a peculiar charm of manner which endeared him to all. His untimely death has robbed the Department of a young officer of great promise, but he died as he would have wished—a soldier's death.

In Memoriam.

The late Lieut. E. J. Woodhouse, M.A., Dip. in Agri. (Cantab.), F.L.S.

Dulce et decorum est pro patriâ mori.

TESTING NEW CANE SEEDLINGS IN NORTH INDIA.*

BY

C. A. BARBER, Sc. D., F. L. S.,

Government Sugarcane Expert, Madras.

THE work at the Cane-breeding Station at Coimbatore has now reached a stage when a closer connection is needed with sugarcane farms in various parts of India.

The object aimed at in founding the station was to obtain better varieties of cane than those at present grown in India. But this is complicated by the fact that these canes are divided into two very well-defined classes—thick tropical and thin indigenous ones—which have to be dealt with separately. There are already many excellent thick canes in the country, while the thin ones are generally of very inferior quality, but numerous seedlings have been obtained in both classes.

To obtain thick cane seedlings of promise is merely a matter of routine, and a large number have been raised, some of which it is hoped will be of value in agriculture. The raising of the thin seedlings, or such as would be needed to replace the indigenous class, is much more difficult, and, because of the much greater area under these, their production has received most attention.

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* A Note submitted to the Tenth Meeting of the Board of Agriculture in India held at Poona in December 1917.

The following is an approximate summary of seedlings considered suitable for North Indian conditions, which have been obtained each year up to the present time :—

	Probably suitable	Number of seedlings grown to maturity	Total number of seedlings raised
1911-13	0	48	48
1912-14	3	2,067	10,000
1913-15	4	2,400	20,000
1914-16	10	3,400	30,000
1915-17	15	4,100	30,000
1916-18	(100-300 ?)	4,800 not yet analysed	99,000

From this table it is seen that, with the current cropping season, there will be a great expansion in the number of seedlings considered suitable for North India, and there is every prospect of this number being steadily kept up each year in the future. The number of seedlings raised this year and now approaching maturity, which may produce varieties of value under North Indian conditions, is 2,800. These are chiefly crosses between thick tropical canes and hardy Indian ones, or "rogues" of thick canes. And it is worth pointing out that we have in the seedlings raised also made a distinct advance to the solution of the problem of obtaining varieties suited to the very different conditions in North Indian sugarcane tracts. Taking, for instance, three canes as typical of such tracts, *Katha* for the Punjab, *Saretha* for the eastern portions of the United Provinces, and *Pansahi* for Bihar and the contiguous part of the United Provinces, we have the following seedlings growing :—

Punjab, 200 seedlings obtained by crossing *Katha* and *Kansar* with thick canes. We shall probably obtain, from these, 20 varieties worth trying in the Punjab, while some of the next series will also probably be worth considering.

United Provinces, 800 crosses between *Saretha* and thick canes, which are likely to yield at least 50 worthy of further trial.

Bihar, 600 crosses between *Pansahi* and thick canes, from which we may reasonably expect 40 varieties suitable to the Pansahi tract.

Our recent success is mainly due to two causes—the more effective control of the flowering of the cane varieties, and a careful discrimination of suitable "mothers." A further factor is the use of "rogues" as parents. In each crop of thick cane seedlings there usually occur a small percentage of seedlings differing entirely from their parents and simulating the thin canes of North India. These are very vigorous but of low sucrose content; they flower very readily, have abundant pollen, form seedlings in profusion, and flower earlier than the indigenous canes and more or less at the same time as the thick canes. They have been freely used to cross with good thick canes, and a large number of seedlings have been obtained by this method.

This portion of our work thus also enters the routine stage, and it becomes necessary to consider the best means of testing the fitness of these seedlings in the field.

It must be emphasized that the work on the Cane-breeding Station is very different from that in tropical sugar countries where only thick varieties are aimed at. A yet more important difference is that the seedlings are wanted for places whose climate and soil are very different from those at the station.

While the Cane-breeding Station is eminently suited for obtaining masses of cane seedlings, the first object aimed at, it is poorly equipped for testing these seedlings afterwards. Although constantly being improved, it has no good plantation land, and the sucrose in the juice varies a good deal from year to year in the same seedling or variety. This variation will be seen from the cases selected below :—

	1913-14	1914-15	1915-16	1916-17
	Per cent.	Per cent.	Per cent.	Per cent.
M2	13·18	12·21	13·40	10·17
M21	12·50	15·07	13·96	12·59
M45	15·81	11·74	15·55	12·74

There are similar, though less pronounced, differences in vigour year by year, partly due to rainfall and partly to the part of the farm on which the seedlings are grown.

The sucrose readings on the Cane-breeding Station, as already pointed out elsewhere, are also low:—

		Cane-breeding Station Per cent.	Central Farm, Coimbatore Per cent.	Jubbulpore Per cent.
Thin canes M2	...	12·21	14·58	15·21
M19	...	13·26	16·75	12·74
M45	...	11·74	17·78	14·71

		Cane-breeding Station Per cent.	Palur Farm Per cent.	Dacca Farm Per cent.	Jorhat Farm Per cent.
Thick canes B147	...	15·88	17·73	16·47	17·59
B208	...	16·76	19·93	18·62	17·77

Arrangements are already being made whereby the thick cane seedlings will be tested elsewhere, and a piece of land is being acquired in the neighbouring wet land area for the furtherance of this part of the work. For testing the thin cane seedlings and those obtained by crosses between thick and thin varieties, it is proposed to enter into negotiations with certain North Indian provincial stations where there is the chance of accurate chemical control, drafting successive series of likely seedlings to them for further growth. There should be little difficulty in growing, say, 50 seedlings in rows on such farms, and testing them as to vigour and sugar-content.

This is a change of policy from that laid down. It was proposed to grow the seedlings for three years on the Cane-breeding Station before distributing them. But the exceedingly variable results obtained in successive years render this a waste of time, as we are sometimes altogether doubtful after the three years as to the relative value of the seedlings grown, and we have reason to suppose that their behaviour elsewhere will be quite different.

The seedlings thus far grown to maturity are numbered "Madras, 1—17,000." These figures will increase year by year and are cumbersome. Besides this, confusion has already arisen between Madras seedlings and Mauritius seedlings grown in India, such as Maur. 1237, 55, 15, 16, 30, 33, 131. It is suggested that a new series of numbers be started of such canes as are, after testing in the Provincial farms, considered worthy of trial by the ryots in

the field. These will obviously be far fewer, and the numbers will be much easier to deal with and remember. The new series may be named after the Cane-breeding Station and termed "Coimbatore Seedlings" (Co. 1, 2, etc.).*

It is proposed to commence this distribution during the current season with, say, a dozen varieties, and this will be followed later on by others as the first ones are rejected. Suggestions are invited as to which Provincial Departments will agree to co-operate with the Sugarcane Expert and enter into this arrangement.

(A demonstration of the various classes of seedlings that are being raised was made at the Meeting of the Board of Agriculture at Poona.)

APPENDIX.

The following circular has been issued with the seedlings since distributed from the Cane-breeding Station:—

Owing to our success in the past two seasons in obtaining desirable crosses between tropical canes and thin Indian varieties, it has been decided to start a tentative distribution of some of these to Provincial farms. As there are fourteen or fifteen of the latter who have intimated their desire for seedlings, the material available is unfortunately small, but it is hoped that this will not recur. In sending these out a certain amount of selection has been made, those for the Punjab, for instance, differing markedly from those for Bihar in parentage, thickness, and early ripening. It is important that the period of testing should extend for several years, because it takes some time for a seedling to accommodate itself to the vegetative mode of reproduction, as well as to acclimatize itself to the very different conditions of soil, temperature, and moisture in its new surroundings. As an instance, a certain cane was distributed because of its rich juice; it refused to grow more than a couple of feet in length for the first four years, but was kept on because of its juice; in this the fifth year it has suddenly grown

* On further consideration it appeared best to attach Coimbatore numbers at once to the seedlings selected for distribution this year, as the proposal to alter the numbering after distribution would be unworkable. This has accordingly been done.

well and the juice does not seem to have suffered by the change. There are numerous instances, in the Indian experience of the past twenty years, of such gradual acclimatization.

We have from time to time obtained a series of Java seedlings specially selected for Indian conditions and as these are now receiving marked attention and have given good results, especially in Shahjahanpur, Mysore, and the Central Provinces, the new Madras seedlings should be compared with them. These Java seedlings are therefore widely distributed for this purpose, besides their own intrinsic merit. They have been in the country for six to seven years and have been grown on the Cane-breeding Station from its start, and are most of them at least twenty years old. It is important, from what has been said above, that this should be borne in mind when they are compared with the Madras seedlings.

It is hoped that the results obtained in different places will be communicated in due course, as this will enable us the better to judge what class of seedlings is likely to succeed in different parts of the country. The Madras numbers (of seedlings grown to maturity and analysed) will this year considerably exceed 20,000, and as these figures are cumbersome it has been decided to institute a new series for such as are being distributed, "Coimbatore" taking the place of "Madras." These numbers will commence with the present distribution. The six seedlings sent out four years ago were intended to act as a guide to the growth of Madras seedlings in different parts of the country, and, having now served their purpose, may be discarded.

THE TREND OF INDIAN AGRICULTURAL EXPORTS.

BY

A. C. DOBBS,

Deputy Director of Agriculture, Chota Nagpur.

THE distance of India from the principal ports of Europe and the reduction of shipping facilities have combined with the development of trade across the Pacific to lessen the effect of the war on Indian agriculture. The tracts that produce wheat, cotton, sugar, and indigo have no doubt benefited by the higher prices of those staples, and their area has been extended at the expense of oilseeds, the value of which has fallen, but the general ratio of prices of the ryot's produce to those of his requirements has not seriously changed, nor has the general level of wages risen owing to the diversion of any considerable amount of labour to military occupations. On the other hand, the war has undoubtedly interfered with, and in fact almost temporarily arrested, the normal secular change of prices that has been in progress since the first railways were made in India. When normal conditions are restored, there is every reason to suppose that this secular change will be resumed and intensified, and a few speculations as to the nature of the change, and its probable scope in the near future, may therefore be of interest to a Department which must look forward a decade for the results of its activities.

The contrast between India as an agricultural country and the western industrial world is marked, and is likely to remain so until coal becomes a minor factor in industrial production. As long as coal remains the all-important factor in raising and maintaining the standard of living above the point at which the necessary minimum

of food and warmth is assured to all, so long will India remain primarily agricultural in character as compared with countries where coal is relatively abundant. Before the use of coal when the production and distribution of food was effected entirely by the consumption of a portion of the food produced, periodical war or famine were alternatives which a settled population had perforce to contemplate. The fear of famine has recently been almost exorcised from India, and her resources in coal and other forms of power are probably sufficient to enable her to maintain an efficient system of communications at a cost which, in view of the density of the population in cultivated tracts, is likely to compare favourably with the cost in countries where the population is more diffuse. But beyond this, it seems probable that industrial organizations on a large scale will be limited to the few places that are particularly favoured in the matter of supplies of power and raw material—a generalization that is supported by the exceptional prominence of the few great non-agricultural industries in India, such as the Kolar gold-fields, the Sakchi steel works, and the Bombay cotton and Calcutta jute mills.

This being so, the influence of industrialism on India is likely to be, so far as the near future is concerned, mainly external, and the sufficiency of the coal supply for purposes of internal transport will only serve to accentuate the contrast and intensify the reaction between foreign industries and Indian agriculture.

The nature of the effect on Indian agriculture can be judged from the change that has already taken place since the opening up of the country by railways—the extension of the cultivation of a limited number of great staples for export. Cotton, wheat, jute, tea, groundnuts, and other oilseeds almost exhaust the list, but the effect of their export in raising prices and wages in the districts concerned is already very considerable.

There are two ways in which the war is likely to affect this development. Firstly, by converting Europe from a creditor to a debtor continent it will inevitably cause an outward pressure of population towards other temperate areas, and thus lead to more intensive cultivation of vast expanses of hitherto only half-farmed

land in those areas. Secondly, it has already led to a crystallization of industry in huge organizations which will be developed on lines that are far more economical of labour than has hitherto been the rule outside America. The population of Europe will spread over the temperate areas, and the standard of living of the majority will rise very rapidly. It is quite possible that—measured in the products of industry—wages and the value of food, fuel, and agricultural products, among nations of European stock as well as in Japan, will have doubled between the years 1914 and 1924.

India will get her cloth and imported machinery and manures at a less cost in terms of her agricultural exports, and the ryot will have a greater inducement to grow staples for export after his own food requirements have been met.

From the point of view of the Agricultural Department, the important point is to recognize the growing importance of export staples, and to anticipate, as far as may be, the demand for such agricultural products as seem likely to pay best under the new conditions. There are innumerable small crops—inferior millets and other cereals, and pulses—which give small yields and are now grown at considerable labour for local consumption ; it is reasonable to suppose that with prices of crops, which give a much higher money return, rising, as compared with prices of artificial manures and implements, the area of those smaller crops will decrease indefinitely.

On the other hand, there will be a growing demand for such tropical and sub-tropical products as coconuts, rubber, tea, coffee, cotton, and oilseeds of all kinds.

The great variety of species of plants cultivated in India under special conditions for local consumption is likely to give way to an equally great variety of races of fewer main species of commercial importance, the value of which will be fixed by world standards instead of by local peculiarities of soil and market.

More detailed speculation with regard to this general proposition should enable workers in each main agricultural tract to pick out with some assurance the crops to which special attention should be given, but there are one or two fundamental factors of the European demand which narrow down the enquiry considerably.

First comes the question of freight ; bulk for bulk, and weight for weight, the most expensive products will of course bear the cost of freight most lightly, and of non-perishable staples not already exported those that have the highest inherent value are most likely to find a market abroad. Secondly, there is the probability that the northern races will increase the out-turn of the staples of the temperate areas and rely on southern latitudes chiefly for the products that suit the characteristic climates of the tropics and sub-tropics. Apart from such purely southern products as coffee, tea, coconut, rubber, and cotton, there are a large number of crops grown in India which require a definite warm dry period in which to mature their seed. The more important of these are pulses and oilseeds. These crops have been comparatively neglected in India, but they have a peculiar value in view of a growing trade with the temperate areas, because, with the exception of milk and meat for the production of which those areas are specially adapted, very few nitrogenous and fatty products are grown in northern climates, while the intensive production of meat and milk requires the feeding of cattle on a relatively high nitrogenous diet. The nitrogenous and fatty constituents of cattle foods cost in England about three times as much as starches and sugars, while in India the difference is much less ; and this fact, combined with the inherent calorific value of fats and oils, which is nearly $2\frac{1}{2}$ times that of starch, assures an increasing external market for Indian pulses and oilseeds as compared, for instance, with rice which consists almost entirely of starch, or wheat and barley which can be grown as well or better in temperate climates.

From this point of view, groundnuts are likely to become even more important for export after the war ; and the varieties of soybeans which are the chief, if not the only other, leguminous oilseeds should not be lost sight of ; while anything that can be done to increase the area of pulses in general, will go towards maintaining the fertility of the land in the face of the drain that the export of non-leguminous oilseeds undoubtedly causes.

Hitherto the Agricultural Department has devoted itself chiefly to increasing the out-turn of the three crops that are perhaps

more exhausting than any others—cotton, wheat, and sugarcane—and the suggestion may be hazarded that the introduction of mineral manures for leguminous crops, combined with the selection of heavy yielding varieties that can be grown and harvested with a minimum of labour and risk, is both essential if the fertility of Indian soils is to be maintained at the level required for the continued production of the improved staples already introduced by the Department, and is likely to be more directly profitable in the near future than any other line of work.

AN ACCOUNT OF SOME EXPERIMENTS IN LUCERNE CULTIVATION AT SAHARANPUR REMOUNT DEPÔT.

BY

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Army Remount Department.

ALTHOUGH one of the most valuable fodder crops of warm climates, lucerne is little grown in India, except on Government farms, or as a market garden crop in the neighbourhood of cantonments. Even in these instances the area cultivated is comparatively small. The reason for this is that lucerne is supposed to need an excessive amount of water which can be utilized more profitably in irrigating a larger area of other crops.

In Remount Depôts lucerne is usually grown by the ridge system, on the ground that it will not survive the rains when sown on the flat. Ridges look nice, and any losses are quickly and neatly repaired by fresh sowings in the autumn ; but in some climates these losses are considerable, and the sowing returns for the last 15 years show that at Saharanpur lucerne is at best a biennial. The question therefore arises whether it might not be more profitable to grow it broadcast as a rotation crop, and thus make use of its well-known manurial properties. By this system the labour of making and maintaining ridges would be saved, and the cost of cutting reduced, while, should it be found to yield a good return with few irrigations, the area under lucerne cultivation might be largely extended.

In November 1916 a series of experiments were started in this depôt in order, firstly, to ascertain whether lucerne would grow

successfully with a small amount of water ; and, secondly, to test the respective merits of the ridge and broadcast systems. Eight plots were laid out—three ridged and five broadcast—on sandy loam soil. By an unfortunate mistake an excessive quantity of seed was sown in the broadcast plots, and although this greatly lessened the value of the experiments, the results are nevertheless interesting.

The ridged lucerne was treated in the usual manner, except that water was restricted. The broadcast received one hand weeding when the plants were small, and all subsequent cleaning was done with harrows. Cuttings were usually made by sickle or scythe, but the whole crop was *cheeled* (scraped) three times—twice before the rains to eradicate dodder, and once in November to clean the ground.

Although none of the plots received more than eight waterings during the twelve months, the plants did not appear to suffer from lack of moisture, and the losses incurred may be ascribed to three causes :—Firstly and chiefly, to the steps taken to eradicate dodder, more especially in plots 2 and 3 ; secondly, in plots 2 and 5 to too deep cultivation ; and thirdly, to some extent to water lodging during the rains.

Since no weeding or harrowing was done in the rains, it is necessary to make an allowance for grass. The following estimate which is based on tests slightly favours the grass at the expense of the lucerne :—

Plots 3 to 8 (sown on fallow land). For July, August, September, October, 3 parts grass to 1 of lucerne. For November $\frac{1}{4}$ grass.

Plot No. 1 (sown on site of old lucerne garden). For July to October $3\frac{1}{2}$ grass to 1 lucerne. For November $\frac{1}{2}$ grass.

Plot No. 2. For rains $\frac{4}{5}$ grass and for November $\frac{2}{3}$ grass.

During the rains the lucerne was cut whenever the grasses appeared to be getting too strong, and the mixed crop was made into ensilage, which has proved of excellent quality. After every

cutting the lucerne was the first to recover, and had made a good growth before the grass began to overtake it.

In the early summer dodder attacked the lucerne very severely, and it was feared that the whole crop would be lost. Digging out was first tried, but the parasite was too widespread for this remedy to be effective. Burning litter on the affected areas was next tried; widely in plots 2 and 3 and to a less extent in other plots. The results were disastrous to the lucerne. Finally, at the suggestion of Major Hewitt, A. R. D., *cheeling* (scraping) was resorted to, and this proved successful.

As very full information is given in the statement at the end, only a few remarks on each plot will be necessary.

Plots 1 and 2 were sown on land where lucerne had died a few months previously. Grasses appeared in them early and they were throughout less clean than the other plots.

Plot No. 2 had been ruined in the attempts to eradicate dodder, so at the end of May it was given a thorough and deep cross cultivation to see if this would clean it. The grass had been established too many years, however, to suffer any permanent damage, and the only result was the destruction of more lucerne.

Plots 3 to 8 were sown on fallow land and were clean until July when rain grasses sprang up thickly, and *dub* (*Cynodon dactylon*) made its appearance.

Until May, No. 3 which had been seeded 40 lb. per acre was by far the best plot, but, like No. 2, was ruined by the burning and digging to get rid of dodder.

Plot No. 5 only received five waterings during the twelve months, and produced 71,722 lb. of green fodder per acre, of which 42,784 lb. are assessed as lucerne and the balance as grass. In May, half the plot was deeply cultivated to see whether a thorough stirring of the soil would strengthen the growth. The experiment proved a failure and resulted in a permanent reduction of 25 per cent. in this half of the plot.

Plot No. 7 was limed some months previous to sowing and eventually produced the largest return.

Plot No. 8 was sown on inferior land containing patches of *kalar* (alkali). It was seeded with a nurse crop of barley, and received no hand weeding; a large mixed crop was cut in February.

At the close of the rains the lucerne in all plots was good and healthy, although the ridged plants appeared bigger and stronger than those on the flat. The thorough harrowing given after the last cutting has, however, been beneficial, and the difference is now less marked. The returns from both systems, even after making the necessary deductions for grass, would be considered quite satisfactory for lucerne grown under heavy irrigations, and the results would have been still better but for the unlucky attack of dodder.

It will be interesting to compare the yields of these experimental fields with those of oats and sorghum, the two winter and summer crops chiefly cultivated in Remount Depôts. The most convenient method of comparison will be to take Kellner's starch equivalent values for each fodder, in spite of the fact that Kellner ascribes a very much lower feeding value to lucerne than do American authors and that Indian conditions probably more nearly approximate to those of America than of Europe.

The average of Kellner's starch equivalent values of green lucerne in all stages is 8·73, of oat hay 35·2, and of sorghum 8·1. His lowest value for grasses is 9·9; this is for good irrigation meadows and would appear to be the most suitable for rain grasses.

From Table I below, it will be seen that the return obtained in these experiments for each acre of lucerne is greatly superior to the combined average yearly yield of one acre of oat hay and one acre of imphee (Sorghum), and, although the seed is expensive, the balance of profit is in favour of the lucerne. The average yield of oat hay in this depôt is 4,480 lb. with a starch equivalent of 1,577; that of imphee is 22,930 lb. with a starch equivalent of 1,857. The starch equivalent value of these two crops together therefore is 3,434. Plot No. 4 gives the lowest yield in these experiments with 60,436 lb. green fodder, having a starch equivalent of 5,572 for the mixture. The yield of No. 7, the best plot, is calculated at 8,000 starch equivalent.

Although these lucerne fields have given large yields with very little water, yet it is not safe to assume that the results would always be similar. The rainfall this year up till July was slightly below normal, but the summer was exceptionally cool, with numerous cloudy days and an entire absence of hot winds. That the conditions generally were unusually favourable is proved by the fact that the average yield per acre of lucerne for 1916-17 throughout the depôt was the highest recorded for 16 years. The experiments, however, are distinctly encouraging and justify further investigation.

TABLE I.

Showing details of out-turn in lb. per acre.

	Plot No.							
	1	2	3	4	5 (A & B)	6	7	8
December 1916 ...	231	...	...	...	...	...	...	...
January 1917 ...	256	4,006	8,114	583	3,237	461	...	...
February 1917 ...	...	...	...	...	2,456	...	3,985	12,262*
March 1917	5,289	6,230	9,520	4,207	7,170	6,588	...	...
April 1917	5,688	10,178	14,867	5,323	9,447	5,956	18,520	14,698
May 1917	8,354	2,898	1,387	8,277	4,117	9,253	4,855	3,114
June 1917	5,411	782	7,376	5,077	3,963	5,320	7,087	5,719
July 1917	22,279	18,726	15,167	12,379	12,672	3,422	..	...
August 1917	...	...	...	...	...	16,867	22,564	13,405
September 1917 ...	13,970	11,777	13,947	10,313	14,963	19,096	16,205	13,427
October 1917	11,588	9,693	11,720	9,410	9,574	14,351	9,487	8,254
November 1917 ...	6,570	5,241	4,453	4,867	4,123	4,337	3,953	2,939
Total green fodder (Lucerne and grass mixed)	79,636	69,531	86,551	60,436	71,722	85,651	86,656	73,818
Deduct for grass ..	39,397	35,651	31,738	25,293	28,938	41,386	37,180	27,049
Balance pure lucerne .	40,239	33,880	54,813	35,143	42,784	44,265	49,476	46,769
Starch equivalent value of lucerne and grass mixture	7,413	6,487	7,927	5,572	6,600	7,961	8,000	6,761

Average yield of 1 acre Oat hay— 4,480 lb. Starch equivalent = 1,577
" " " " " Sorghum— 22,930 " Starch equivalent = 1,857

Starch equivalent value of 1 acre Oat hay and 1 acre Sorghum 3,434

* Lucerne and barley mixed

TABLE II.

Showing details of sowing and watering.

Plot No.	System	Area of plot in acres	Date of sowing	Seed sown per acre	Dates of waterings								Total No. of waterings	Out-turn of green fodder per acre	Remarks
					Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June			
				lb.										lb.	*Rainfall*
1	Ridge	1·99	10th Nov.	13	10	5			14	25	26	13	6	79,636	Month / During the year / Average for 20 years
2	Broadcast	2·15	14th ,,	32	14	1			14	9 & 24	8	14	7	69,531	
3	,,	1·50	14th ,,	40	14	2			15	11 & 24	28	11	7	86,551	
4	Ridge	1·66	14th ,,	13	14	1			17	10 & 29	11 & 25		8	60,436	
5 (A & B)	Broadcast	1·62	15th ,,	48	16	5			21	26	29		5	71,722	
6	Ridge	1·66	15th ,,	13	16	2			19	27	8 & 25	10	7	85,651	
7	Broadcast (limed)	1·17	15th ,,	26	16	7			19	4 & 28	5 & 29	13	8	86,656	
8	Broadcast (with barley)	1·85	15th ,,	26 lucerne 32 barley	16	7			18	8 & 28	5 & 30	12	8	73,818	

Month	During the year	Average for 20 years
November ...	...	0·25
December ...	...	0·57
January ...	0·5	1·37
February ...	...	1·10
March ...	0·6	0·81
April ...	0·9	0·45
May ...	0·7	0·71
June ...	2·0	4·17
July ...	14·0	9·80
August ...	8·8	9·49
September ...	11·0	5·95
October ...	6·0	0·66
TOTAL ...	44·5	35·33

THE SPREAD OF CO-OPERATION IN THE PUNJAB.

BY

C. F. STRICKLAND, B. A., I. C. S.,

On Special Duty in the Office of Registrar of Co-operative Societies, Punjab.

I. Introduction.

Before the passing of the Co-operative Credit Societies Act of 1904, a few societies had been founded in the Punjab through the zeal of individual officers. Three were created in the Multan District in 1898 by Mr. (now Sir) E. Maclagan and Captain Crosthwaite, and registered in Calcutta under the Companies Act. Five were set up in the present Mianwali District in 1900 by Captain Crosthwaite. Of the latter, four are still existent though lack of supervision has left them weak. Two of the Multan societies have perished, but Thatta Ghalwan, after a long period of work with varying efficiency on a basis of mixed grain and cash dealings, has arisen in new strength. The Panjawar Society of Hoshiarpur District, dating from 1892, was, and still is, an unregistered and unrecognized association, which will be described later.

By the orders of Government the experiment of co-operation was to be tried in the five selected districts of Rawalpindi, Mianwali, Montgomery, Karnal, and Hoshiarpur. In the following year permission was given to include Multan, Shahpur, Ludhiana, Gurdaspur, and the Rupar Tahsil of Ambala; and the number of selected districts was rapidly increased until the principle of limitation was abandoned. For reasons accidental or otherwise, no serious attempt was at this time made in Rawalpindi, which remained virgin soil until 1913. No large success was apparently attained in Mianwali

and Montgomery, though of 15 early Mianwali societies 12 are still nominally or actually alive, and the number registered was at one time twice as great. Karnal proved a failure, and generally speaking has continued to be unpromising: the Registrar in 1905 applied this description to the whole Eastern Punjab. In this statement he generalized too freely, for from 1910 onwards Hoshiarpur which had hitherto lagged behind its neighbours made rapid strides and is now one of the areas in which societies are not only most numerous, but most truly co-operative.

The difference in the rate of progress was largely due to personal reasons. A single-handed Registrar could effect little without keen propagandists, official or non-official: Ambala District flourished under Mr. Gladstone and Gujrat under Diwan Narendra Nath as Deputy Commissioners; Fakir Iftikhar-ud-Din was valuable as Settlement Officer, Hoshiarpur; while Shaikh Firoz Din, Extra Assistant Commissioner in Gurdaspur, and Pal Singh, an enthusiastic Jat zemindar of Jullundur and Lyallpur, were responsible for multiplication of societies in the districts named. It cannot, however, be said that such multiplication was always of real value, and a number of "paper" societies were cancelled without enjoying more than a nominal life.

At the present time the movement has penetrated every Punjab district except Dera Ghazi Khan, and it has been found that no difference of caste or clime renders the Punjabi peasant of the plains or hills inaccessible to co-operative teaching. The least prosperous regions are Montgomery, Multan, Muzaffargarh, Mianwali, Attock, Jhang, Kangra, Gurgaon, the fringe of the province, and including some of its most backward parts. It is obvious, therefore, that only effort and an adequate staff are needed to bring the laggards up to the general level. Most advanced at present are Gurdaspur, Jullundur, and Hoshiarpur, whose growth is shown in the following table:—

	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
Gurdaspur	5	68	59	64	159	202	267	544	585	571	557	555	
Jullundur	7	44	53	89	197	318	415	453	460	460	1461	457	
Hoshiarpur ...	3	6	8	11	12	61	122	287	418	452	449	439	43[illegible]

The slight retrogression in 1915 and 1916 is due to an elimination of weaklings and a process of consolidation.

The progress of the Punjab as a whole is given below :—

Year	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
Societies	12	24	177	258	316	706	1093	1769	2845	3333	3337	3391	3495

II. Types of Societies.

A. Interest was aroused by a scheme adopted in 1892 in Panjawar village of Hoshiarpur District, whereby the entire control and management of the common land was handed over to quasi-permanent trustees, loans being made from the profits of cultivation to redeem the lands and to repay the debts of the co-sharers. The society, though unregistered, has been abundantly successful from the financial point of view, both in enhancing the value of the land and in relieving the associates from embarrassment ; but its proceedings are not in all ways co-operative, since the trustees are not at all times responsible to the members assembled in general meeting and dealings are not confined to members. An association of this nature needs influential leadership ; a single recalcitrant sharer in the common land can block its action : hence the type has not found exact imitators. Certain villages in Sialkot District devoted the entire proceeds of the sale of *shamilat* (co-parcenary) trees on an embankment to their registered societies ; the resulting influx of money available for loans was not in all cases beneficial, and the largest of these societies is under liquidation. Three Gurdaspur societies depend wholly or largely on the income of their *shamilat*.

B. The proposal originally most popular in the Western Punjab was to contribute a fixed or unfixed amount of grain for a period usually of ten years : loans were issued and repaid in either grain or cash. This type was in early years to be found in Mianwali, Muzaffargarh, and Jhelum, and occasionally in Montgomery and Multan : a few specimens in Mianwali and Muzaffargarh survive, but the majority have either faded away or been converted with more or less reluctance to a cash basis. The profits on grain dealing are normally very much higher than on cash payments, without

any hardship to the borrower, on account of the wide divergence between sowing and harvest prices : it is essential that grain be either promptly sold or stored with the utmost care in order to avoid damage and the suspicion of irregularity. A grain basis is acceptable in areas where Mahomedan objections to interest are strong : it offers, however, little inducement to the wealthier landowners, even of the peasant class, whose varied requirements can only be met by a free grant of cash loans both at harvest and at other times.

This "Mianwali" type never received a fair and full trial in the Punjab ; it sprang up in districts where, through accident and intention, staff could not be provided, and the societies had decayed or learned unbusinesslike methods before adequate inspection was available. Under good supervision a society working in mixed cash and grain should serve a valuable purpose both in co-operative credit and in the provision of pure seed.

C. Another attempt to escape from the difficulty of interest among Mahomedans gave rise to the "deposit" type, in which a certain number of members, usually a handful of wealthy men, supplied the funds in fixed deposit for a term of years, taking a share in the profit, which was held not to be interest. The most noteworthy case was the Kharal Fund of Mehrpur in Montgomery District under K. S. Kamir Khan. This society, at one time outwardly flourishing, recently failed, partly because its operations were extended over too wide an area, and partly because on the transfer of the zail (agricultural circle) to another district the local inspecting staff failed to learn of its existence and lend it aid. Societies of this description are fundamentally unsound ; non-depositing members, admitted for a trifling fee, fail to realize their responsibility ; they appear to be only borrowing from tribal leaders as their fathers and grandfathers have done, and no co-operative sense is developed. The principle of paying a share of profits to depositors is maintained in the Ludhiana Weavers' Society, where, however, all members are made to contribute shares.

D. The type which eventually became predominant originated in 1906 in Gurdaspur and other districts of the East Central Punjab.

and is a modification of the Raiffeisen Society, sometimes called the Indian Luzzatti model. Shares are paid in ten annual instalments and, though the value of a share is low, form a large proportion of the capital. The accumulated profits or reserve fund may be used as working capital during the 10 years period. At the end of the 10 years, share money may either be withdrawn, or, in the more recent institutions, left in the society; three-fourths of the profits may be credited to the members. A dividend in cash after this initial distribution was usually allowed by the by-laws, though contrary to the rules of the Local Government; the defect has now been remedied by new Government rules. Liability is unlimited and the control democratic; mutual supervision and responsibility are enforced. Since share payments are annually made, deposits do not reach a high figure in most primary societies in their early years. The rate of dividend is now limited by rule to 10 per cent. in order to combat the profit-seeking tendency, and affluent societies are encouraged to reduce the rate of interest on instalments punctually paid.

E. An old society in Multan District has resolved to abolish interest altogether and recover principal only. Every member will pay a small annual contribution, and in order to compel punctuality and inculcate thrift, a fixed penalty will be charged on debts in arrears, and a fixed bonus paid on deposits. The experiment may prove highly attractive to scrupulous Mahomedans, but can only be undertaken after the accumulation of permanent funds.

F. The prevailing industrial type is that of the weavers' supply and sale society. Yarn is bought from the Weavers' Central Stores and supplied to members at the lowest price; when possible, a shop is opened for sale of the members' finished product. Shares are contributed, but cash loans are now rare. The societies are gradually accepting the idea of distributing profits mainly as a rebate on raw material sold to members and as a bonus on finished articles bought from them. Profits are surprisingly large, though the capital is at present of moderate amount.

G. Little need be said of Central Banks and Unions. The former were in all cases founded by individual shareholders, but affiliated societies are buying shares and taking part in the control, while the admission of new individuals is discouraged.

Unions in the Punjab are financing bodies of limited liability, and at a certain stage of development were found to compete with Central Banks. A number of the less active have now been absorbed, and as they perform little or no supervising duty their number is likely to decrease.

III. The Law, the Rules and the By-laws.

The first Act (X of 1904) was admittedly experimental and aimed only at establishing a system of co-operative credit as the simplest form of the co-operative idea. Its provisions were confined to the minimum required for putting societies on a legal basis, arranging for a certain supervision, and affording scope for the grant of privileges. All further assistance and limitation was to be at the discretion of Local Governments which would notify rules, and of the Registrar who would scrutinize the by-laws at the time of a society's registration. No attempt was made to legislate for secondary or central institutions, or for primary societies aiming at other objects than credit. It was not legal to levy a fee for audit or to devote a portion of the profits to charity. Further, by a curious oversight, the Registrar could refuse to register a society the by-laws of which he considered unsatisfactory, but had no power to control or prevent subsequent modification of the by-laws.

These and some minor defects were remedied by Act II of 1912 (the Co-operative Societies Act) which contemplates all forms of co-operative associations. Even the later Act, however, is couched in general terms and is largely permissive rather than mandatory. All detailed control is exercised through rules and by-laws. The need for a prompt method of land redemption was felt at an early stage, and has been to some extent satisfied by Act II of 1913. The grant of *taccavi* to societies under the Land Improvement Act and Agriculturists' Loans Act has been the subject of recent correspondence with the Punjab Government. It has been resolved

that *taccavi* grants for short terms under the Agriculturists' Loans Act may be freely made, and such advances could no doubt be given either to Central Banks or to Village Societies. Members of borrowing societies will not, however, be debarred from direct access to Government. Advances under the Land Improvement Act will only be sanctioned when the purpose of the loan can be effected and the loan repaid within 3 or 4 years, and when all the members share in the work or the benefit. Societies are to keep separate accounts of sums so advanced.

The chief omission in the present Act (II of 1912) is that of an effectual and expeditious mode of liquidation: a society which has been brought under liquidation has *ex hypothesi* failed in its co-operative purpose, and the co-operative staff are at present heavily penalized for a fault that is only partially their own, by the cumbrous and tedious machinery of law. In practice the duty of liquidation is directly or indirectly fulfilled in most cases by the heavily-worked subordinates of the Registrar or of a Central Bank.

The rules notified in 1906 by the Punjab Government under section 27 dealt to a great extent with Government loans; the discontinuance of such loans has rendered the provision unnecessary. The desired control over amendments of the by-laws was given to the Registrar, and a scheme of arbitration for disputes was devised. At this time it was evidently anticipated that the connection between societies and the Revenue Authorities would be closer than subsequent developments have rendered it: an extract from a society's papers was to be attested by the *patwari*, arbitrators were appointed through the Collector, and the Punjab Government supported a proposal that arrears of debts might be recovered through the agency of the *tahsil*, a provision which, though *primâ facie* attractive to many, would beyond doubt have weakened the backbone of co-operators.

In 1912 a notification was issued permitting the distribution of three-quarters of the accumulated profits in a society of unlimited liability in the form of non-returnable shares after the period prescribed in the by-laws, the old Act having allowed an eventual distribution in cash.

In 1914 the earlier rules were revised, and additional forms and registers prescribed; detailed instructions for the procedure of liquidation were given, though nothing can remove the inconveniences of the existing method. It was also laid down that arbitrators in disputes should be appointed by the Registrar, and from this time the recovery of debts by arbitration became effective though at first sparingly employed. New rules have during the present year (1917) been sanctioned by Government after publication. The chief improvements aimed at are a simplification of the arbitration procedure by rendering an award final, save for the right of appeal to the Registrar, and enabling it to be executed as a decree, and a more exact definition of the powers and duties of the Managing Committee, a body which had hitherto scarcely any legal status. The distribution of profits in cash with a dividend limited to 10 per cent. is permitted in a society's eleventh year, but an increasing body of co-operative feeling is opposed to such distribution in practice, and emphasis is being laid on the desirability of reducing and perhaps abolishing interest on loans.

The first by-laws of a primary society, framed in the urgent haste of a new movement and without the advantage of local experience, were in many respects defective. In spite of section 8 of the old Act which forbade the distribution of profits, the return of shares with profits was allowed to withdrawing members, and societies with this by-law were founded up to a very recent date. Shares were paid often in grain and were usually withdrawable after 10 years. It was also laid down, perhaps by a curious oversight, that distribution of the full three-quarters of the profit must be made, so long as such dividend did not, before the rate of interest had been reduced to 6 per cent., bring in to any member a sum exceeding his former annual contribution of shares. The rate of interest was at first 9 or $9\frac{3}{8}$ per cent., and later, on the creation of Unions and Central Banks, was raised to $12\frac{1}{2}$ per cent., which is now general except in young societies. Members were freely admitted on payment of fees only without shares, a laxity which produced an unfortunate sense of charity among the poorer members.

The payment of old debts was not originally contemplated as an object for which loans might be given; and, when afterwards included in the stated objects, was for a time forbidden to members of Committees: moreover, no person was to borrow more than one-tenth of the capital. These two by-laws were not maintained, and the latter has only recently been revived: the great stumbling block is the selfishness of the Committee whose members frequently borrow over half the available capital. Efforts to prevent this selfishness are made in various ways, but with only moderate success. The newest by-laws render shares not withdrawable at the will of the shareholder: the taking of personal security is compulsory, and a limit is set to borrowings by a register *haisiyat* (register of economic status), fixing the maximum credit of every member as principal or surety. All members must take shares, and in cash only. Loans may be given for any necessary purpose.

It is interesting to note that though the present by-laws only permit the reserve fund on dissolution of a society to be applied to a public purpose or reserved for a future society in the same area, and the old clause allowing the Registrar to distribute it to the members has been cancelled, yet that by-law was not illegal, since the old Act did not forbid the eventual distribution even of the reserve fund proper, while the new Act only forbids it in the case of a registered society.

The first Central Banks were founded and their shares were subscribed by individuals who had often an imperfect realization of the objects in view. Primary societies were not expected themselves to become shareholders, and large dividends were openly or secretly aimed at and occasionally obtained. As societies have acquired understanding and strength, they have been encouraged to join in membership and participate in management; the issue of shares to individuals has generally been discontinued, a limit to dividends has been more strictly enforced, and the superior voting power of large shareholders is being abolished. Any future Central Banks founded in this province are likely to confine their membership entirely or principally to societies, and a Central Bank for the Murree Tahsil of Rawalpindi is being incubated in this shape.

IV. Direct Help from Government.

The privileges conferred by the Act itself need not be here discussed. In all countries certain simplifications of the law have been devised in order to free the unlearned peasant and artisan from technical difficulties and to give a society a statutory existence, while requiring fewer formalities than from more advanced and wealthy incorporated bodies.

Government has, however, taken direct action under section 28 by exempting the funds of societies from income-tax, and their documents from stamp duty and registration fees. Section 27 of the Act had already exempted many documents from the necessity of registration.

It is generally recognized that while the subordinate staff of audit and inspection should be paid, and, as societies mature in wisdom, controlled by co-operators, a certain amount of superior supervision should be maintained by Government, which cannot afford to trust entirely to private agency a movement so nearly and deeply affecting the welfare of the poorer classes. The services of the Registrar and his Assistants are lent by Government; and except during a short period in 1915 and 1916, when four Inspectors were paid from the contributions of societies, all Inspectors have been employed at the public expense. In special cases, such as the founding and management of industrial societies, or the extension of the movement to Muzaffargarh District where the relations of zemindars and moneylenders had become more than strained, extra inspectors have been supplied above the ordinary scale. Similarly nine sub-inspectors were for a time provided by Government in new areas. It has recently been decided that in future inspectors will be Government-paid, while societies alone must contribute the salary of sub-inspectors. Small grants are occasionally made to pay for secretaries in the societies of illiterate menials.

By a welcome concession of the Government of India, societies are allowed to use Remittance Transfer Receipts and Cash Orders when despatching money to one another: and an experimental

sanction for five years to a rebate of annas 12 in the rupee of money order commission-charges on similar remittances will enable payments from and repayment to Central Banks to be made without summoning representatives of village societies to a remote centre. The privilege of depositing a cash box in the Treasury has been found convenient by some urban societies.

Before the creation of central institutions, Government loans were given to primary societies, but have been discontinued for some years on the growth of Central Banks. During the financial crisis of 1914, and later owing to the stress of war, temporary advances have been allowed to Central Banks and Unions. The total of Government money (in rupees) held at the end of each year by primary and secondary societies, and the proportion borne by such money to the working capital, is shown in the following table :—

1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917
...	3,700	47,300	93,350	103,959	90,519	76,934	73,976	67,558	63,575	128,529	207,639	133,766
...	10·0	18·1	19·4	14·2	5·7	2·5	1·3	0·7	0·5	0·9	1·0	0·7

During the current year a scheme was prepared for a large advance of Government money, whether in the form of *taccavi* or otherwise, to a Central Bank or to primary societies in Montgomery District, where the colonists of the Lower Bari Doab Canal, though incurring debt and in need of co-operative help, do not own their land and can only offer a mediocre security. After some discussion the proposal was abandoned as Government found it necessary to impose in the public interest more stringent conditions as to security, and were able to permit a less unfettered control than was considered desirable in a co-operative movement. The funds are being successfully contributed by co-operators in Montgomery and other districts.

The sphere of Government assistance in India lies in the work of propaganda, organization, and supervision. In the initial stages of a new movement the authority and approval of Government are valuable and essential ; at a later stage direct support gives way to guidance and correction. Subsidies continued when no longer

indispensable will weaken the spirit of self-help, and the accompanying control may hamper free movement. Particularly in this country the excessive use of official agency tends to create confusion in the minds of the ignorant. Government money is regarded as *taccavi*, to be repaid only under compulsion: the society is frequently called a "Government Bank," and the most strident denials fail to remove this belief when firmly rooted. It is, however, probable that an increasing demand for assistance in staff and funds may arise when Central Banks undertake, as they should, the organization of travelling lecturers, of co-operative periodicals, and of experimental ventures in new co-operative forms. When industrial societies of artisans extend their dealings to a wide field, expert advice and practical help will be needed which the societies cannot at first repay. Cattle insurance in an untried area where statistics are not available is exposed to risks which Government will be wise to share. In all co-operative matters the activity of Government naturally increases as the edifice rises higher, but should be as little as possible in evidence to the uneducated mind.

(*To be continued.*)

SOME OBSERVATIONS ON AGRICULTURAL WORK IN EGYPT, AMERICA, AND JAPAN.

II. America.

BY

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(Continued from page 587, Vol. XII, Part IV.)

I was in the United States of America from August 15th to October 5th (1916), *i.e.*, about eight weeks, practically the whole of which I spent in the cotton-growing tracts in the south and in the irrigated areas of Arizona and California where the climatic conditions of cotton growing correspond closely to those of irrigated North-Western India. Government agricultural activity in the States may be divided into two main branches, *viz.*, Federal work, under direct control of Washington, and State work, each State having a separate agricultural department of its own. The Federal Department, in addition to ordinary agricultural research work, also extends its activities to such subjects as investigations in road-building and rural engineering for which £55,000 are allotted annually, Forestry with £1,160,000 and Forestry investigations with £60,000, and Meteorology with £40,000. Market organization has £50,000 and Cotton Standards work £12,000 with £35,000 for Enforcement of Futures Act. The total budget of the Federal Department is £5,000,000. To give an idea of the expenditure and size of State Departments, I may quote the case of Texas where the number of experts employed is 285, or more than the whole of the higher grades of the Agricultural Department in India, both Provincial and Imperial. Of the above number it should be noted that 20 belong to the Federal Department and 101 Demonstration Agents are

paid jointly from State and Federal funds. I spent seven days at Washington interviewing Chiefs of Bureaus and especially every one doing work on cotton. The most interesting feature there to me was the Market Organization Division where the cotton standards are prepared. I spent all my spare time in this section and in the Bureau of Plant Industry.

Cotton standards. The cotton standards are prepared on colour or grade, and consist of nine classes, four above and four below the middle or medium class. No standards for staple have been prepared as yet. These cotton standards, of which a large number of duplicates have now been made, are utilized in settling all disputes with regard to the Cotton Futures Act and are accepted by the whole trade for purposes of settling differences in contracts. The successful working of this seemed to me the finest thing I saw regarding the achievements of the American Department of Agriculture. I made a point of asking the opinion of leading members in the various cotton exchanges as to how these worked, and was told on three separate occasions that my informer himself had been chiefly responsible for the types settled upon : this struck me as a great compliment to the Department.

Controlling crop pests, etc. While a great deal of admirable research work was in progress and a staff of experts were on hand to investigate any new disease, there was practically no organization for controlling or stamping out any crop pest, which would be of direct interest to India. The legislative measures taken, however, on the recommendation of the Bureau, with a view to preventing the spread of disease (*a*) from foreign countries and (*b*) from one State or part of a State to another, seemed admirable. With regard to (*a*), special precautions have been taken to guard against the introduction of cotton diseases. The United States of America imports about 50,000 bales of Indian and Chinese cotton annually. In order to prevent introduction of disease, all this has to be fumigated in large fumigating chambers under Federal supervision. One such fumigating plant was inspected by me near San Francisco. It was a small plant, but could do 50 bales at a time. The fumigating chamber consists of a large iron drum into which the cotton bales

can be run on rails. A small engine and suction pump are used to exhaust the air after the chamber is full of cotton. Hydrocyanic acid gas is then let in, and after a definite exposure the cotton bales are taken out. The method has been carefully tested and is very simple and reliable. In view of the fact that up to recently India has been importing American cotton through which we run the danger of boll-weevil and other diseases which have done so much damage in the States, it seems very desirable that a similar arrangement should be put forward in India. The cost per pound of cotton is extremely small, so that there would be no hardship; what little there is, would act favourably for American cotton grown in the Punjab. As pointed out earlier in this report, Egypt has adopted the more drastic remedy of totally prohibiting the import of Indian cotton to that country. As regards (*b*) above, a tract where disease has appeared is declared infected, and export of that produce to non-infected areas, either in bulk or for seed, is either prohibited or allowed only after proper fumigation and examination by Government Inspectors. Had this matter been taken up in India, it might have been possible to restrict the potato moth, *e.g.*, to Western India where it first appeared. It is now doing a great deal of damage in the Punjab.

Soil surveys. The work carried on in this Bureau is of great general interest and is characterized by a broad and well-defined policy, which quality I find often lacking in many of the activities of the Department. A soil survey may be carried out on a number of different principles, and unless they are conducted in accordance with a general scheme, surveys are liable to convey accurate information only to their author. In view of the future importance of this subject, I would suggest that the Government of India should have a definite policy drawn up by the agricultural chemists, so as to make surveys carried out in the various provinces generally intelligible and comparable for the whole of India.

Cotton cultivation. The cotton belt is remarkable for the concentration of the cotton area—often one sees miles and miles of practically nothing but cotton. In many States there did not appear to be any rotation; and, generally speaking, other crops grown

were poor. This is especially so in tracts where Negroes do all the cultivation. This state of affairs, where so much attention is given to one crop, may be unsound economically ; but has certainly led to a very high state of perfection in the cultivation of this crop. Some of the instructive points gathered from conversation with a large number of planters and Negroes are set down below :—

1. When discussing a crop in the field, the cotton plant was generally looked upon in three sections, *viz.*, " bottom," " middle," and " top." A planter would often point out a field as having no bottom crop, *i.e.*, no bolls on the lower parts of the plant, or again the middle crop may be poor or absent ; and then the whole gamble is on the " top crop," the success of which depends on a late fall. Constant references were made as to the undesirability of excessive vegetative growth. All cotton is sown in lines, and the distance between the lines is generally five and a half feet. I saw many fields where it was six and others where it was under five feet. The distance advocated by the Punjab Department for American cotton is three feet. Most intelligent planters in the States and agricultural officers admitted closer planting could give a better crop, but owing to the high cost of labour and cultivation they could not afford to put it closer. Where this is sown in lines, the ground is not level ; it is slightly ridged before sowing and a very high seed rate—35 lb. per acre—is used as compared to 8 lb. in the Punjab. Various reasons were given for this, the chief being that it was essential to get a good stand at all costs and that the small extra expenditure on seed was a cheap insurance. Thinning is subsequently always carried out : so that the practice would seem to be largely insurance against uneven germination.

2. The most striking thing of all regarding the cultivation is the importance laid on frequent interculture : some planters advocated running the hoe between the lines every 10 days, but the general practice was once every 12 days or fortnight ; and that is done right up to the time the plants begin to bear, *i.e.*, from March or April up to July and August ; in some cases (*e.g.*, in South Carolina) even up to September when the bottom crop has failed and a top crop is expected. If this frequent cultivation is found paying

where labour is so scarce and dear, it should have manifold advantages in India. I am more convinced than ever that the present practice of broadcast sowing and running the native plough once through the crop in the Punjab must be scrapped and in its place a method adopted which allows of organization and a prolonged system of interculture. This has been our main policy in Lyallpur for over four years and is meeting with very encouraging results.

Ridging cotton. As pointed out above, the crop is sown on a broad shallow ridge and not on the level. A similar system tried in the canal colonies had proved a failure at Lyallpur, but this summer a modification was introduced which seems to promise success. Briefly, this consists in subsequent shallow ridging after sowing and furrow irrigation. The subject is of extreme importance from the point of view of saving water and of adopting deep irrigation at less frequent intervals which seems indicated for *kharif* crops like cotton.

Picking cotton. The cotton is not picked until most of the bolls are open. Generally there are two pickings only. The average rate for picking is 80 cents per 100 lb. of *kapas*. A man can pick 300 lb. a day. In an actual case seen by me a carpenter and his wife and four children picked as follows:—

	lb.
Carpenter	300
Wife	200
Four children at 150 lb. each	600
	1,100

This meant an income of 8·80 dollars per day or roughly 27 rupees. In the Punjab there are as many as four to seven pickings and payment is in kind—generally 10 per cent. For picking the above amount in the Punjab payment would be 10 per cent. of 1,100 or 110 lb., and this, when Punjab American *kapas* is selling at Rs. 13 per maund, is worth nearly Rs. 18, *i.e.*, cost of picking in the Punjab is about two-thirds what it is in the States. If we take the cost per acre for say 6 maunds crop in the two countries, it would be Rs. 8 in the Punjab and Rs. 12 in the States. The relation of cost of picking in the States to total cost of raising the crop has been

generally exaggerated—*vide* Todd's *World's Cotton Crop*, page 109. Similarly the picking is much more crude in the States than in India, and the *kapas* as picked contains a lot of opened bolls and locks which, however, are separated from the cotton by the saw gins. The crop in the States remains green up to late in the season and hence in spite of careless picking very little leaf or withered bracts are found in the first pickings which constitute 80 per cent. of the crop.

Ginning. Saw gins are universal except in the Sea Island and long-staple tracts. They seem to be much more efficient than the roller gins for American cotton. One saw gin with 70 saws gets through 7 or 8 bales of cotton a day, *i.e.*, roughly 40 maunds of lint as compared to 7 to 8 maunds for the roller gins. Besides this, a better and cleaner sample is turned out and less supervision is necessary. It is said the roller gin breaks the staple in India, but they have been used in Dharwar in the south of Bombay for many years, and it is significant that up to recently this was the only tract growing American cotton. The saw gins would seem to be unsuitable for *desi* cotton as the lint is more firmly attached to the seed : hence their introduction would tend to keep American free of *desi* cotton. Other advantages offered are that with a modification of the saw gin the short staple attached to the seed could be largely recovered : this is known as " linters " and is at present fetching 4 annas a pound : at ordinary times it is worth 1 anna or more a pound and would well recoup moderate expenditure on its recovery.

Yield per acre in the States. Taking an average crop of 14 million bales of 500 lb. and an acreage of 37,000,000 acres, the average yield works out at 189 lb. as compared to 160 lb. of lint in the Punjab. The average for the Punjab has been taken as six maunds of *kapas* per acre. If we take the whole of India and take the gross crop as 6 million bales of 400 lb. and the area 25,000,000 acres, the yield works out at 96 lb. per acre for India.

Seed selection. A great deal of work is being done on this subject and very great importance is attached to selection. Crossing as a means of improvement is practically ignored. The writer was referred to Mr. Saunders of Greenville Texas as the most successful with new varieties in the Department. A variety called " Lone

Star " seemed to be in chief favour, and yet the area under it was estimated at well under 10,000 acres in spite of free distribution of seed by Congress and other methods, and even this was scattered and lost from year to year for the most part, and no record or trace of it kept. The departmental authorities could scarcely credit the fact that the Punjab Department would be handling seed for 140,000 acres direct this year. The most successful work in introducing new varieties in the States is that of Mr. D. R. Coker of Hartsville Texas, who is a private individual having no connection with the Department, though he was first attracted to the possibilities of this work by Dr. Webber ten years ago when the latter was in the Federal service. The chief reason for Mr. Coker's success is that he is a buyer of fine cotton and is able to give proper value for good staple. When the writer was with him, he saw Mr. Coker buying cotton for 15 cents and for 22 cents per lb. the same day. It is said 95 per cent. of the area under cotton in his county in S. Carolina is now producing cotton of $1\frac{3}{8}''$ to $1\frac{5}{8}''$ staple as compared to 1" which used to be grown there. This experience coincides with ours in the Punjab where the success of American cotton is largely due to our strenuous efforts with American cotton sales. In this connection the writer would note the following experience. While at Washington he gathered the Department were conducting investigations into the reason for differences in price in different markets on the same day. Such differences being only too common in India, the writer made a point of seeing some of these investigators in the cotton tracts. The system adopted was as follows :—The Government official had a small office in the centre in which he was working. Any farmer could have his cart of cotton graded and the staple length written down on a printed card, on condition he promised to return this card after filling in name of buyer and price realized. It transpired that every farmer practically utilized this concession and secured prices in accordance with the quality and length of his staple. The result was a marked increase in good cotton as compared to the previous year. This piece of work seemed to the writer the most significant of anything he saw in the way of cotton work carried out by the Federal Department. There is no doubt that

a chronic state of disorganization exists in the cotton markets in the States and a great deal of scientific work is simply thrown away until the economics of growing good types is taken up less academically and realized from the farmer's or planter's standpoint.

Selection in Sea Island and Long Staple Tracts. In these tracts the planters lay great stress on proper selection. The system is briefly as follows :—One plant is carefully selected after a close examination of a number of promising ones and the following year the seed of this is grown in a separate seed plot. In the second year one plant again is selected from the small seed plot and the remainder used for a larger seed plot in the third year. In the third year one plant is again selected from the smaller seed plot and the produce of the third year plot used for general sowing. Thus on every big estate there will be three seed plots, *viz.*, (1) produce of a plant, (2) increase plot, (3) increase plot. To indicate the importance attached to selection, I may quote the saying of one successful planter on James Island, Alabama, who in complaining to the writer regarding a cyclone—which had recently severely affected him—said he would not have worried over the loss of his crop but his seed plot had been destroyed and that would affect him for years. He was getting 65 cents a pound for his cotton on a regular contract when middling American was quoted at 12 cents. An adjoining farmer, whom the writer also saw, was getting 35 cents. The yield per acre in the latter case was, however, better, but not sufficient to compensate him for the lower price his produce fetched.

Cotton in Arizona (Salt River Valley) and in the Imperial Valley, California. The cotton in these places is grown under irrigation and is a new introduction in these tracts. In Arizona, Egyptian cotton of good quality was being grown, but the area under it was comparatively limited, something like 15,000 acres. In the Imperial Valley the conditions are somewhat similar to the Punjab, though the soil is heavier and richer. The methods of cultivation were very similar to those in other tracts and are described above. Water is given in abundance and the plant develops even more than on rich land in the canal colonies of the Punjab. The writer saw plots here which had given phenomenal yields on planters' estates.

In one plot which was measured, the yield had already exceeded 50 maunds of *kapas* and at least 15 or 18 maunds more could be reasonably expected. This case was the most authentic one regarding high yields that the writer came across and is remarkable. The interests of growers in this region are looked after by the Imperial Valley Long Staple Growers Association, with offices at El Centro run by Mr. A. W. Palmer, the energetic Secretary and Manager. The Association secures daily quotations and sells cotton on commission for growers.

Irrigation investigations. Though the problems of irrigation are not nearly so important or extensive in the States as they are in India, yet a great deal of investigation is being conducted on the question. The writer spent a day at Berkeley University, California, with Professor Adams, who is head of the irrigation work there, and two days at Davis where there is an irrigation experimental farm which is doing good work. A similar and better equipped station exists also at Utah, besides several smaller ones in other centres, with the main purpose of studying irrigation problems. Irrigation schemes are generally in the hands of private companies, and while water is charged for by volume, the rate is so low that little economy in the use of water seems to result. The tendency seemed to be for Government to take more and more control of matters. The problems in the States are somewhat different to those of India, but the subject is being attacked with energy and considerable outlay and in a painstaking scientific manner. It should be unnecessary to point out the moral for India.

(*To be continued.*)

EXPERIMENTS WITH NIGHT-SOIL AS MANURE.

BY

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The actual natural sources of manure which are available in Western India are at the present time very largely, if not completely, utilized. These consist of farmyard—chiefly cattle—manure, green manure obtained by burying growing crops—chiefly sunn-hemp—and in a few localities the green and dried leaves of trees ploughed in or burnt on the surface. The first of these is excellent but, largely owing to its being required for fuel, it is not available in anything like sufficient quantities. The use of green manure is extending fairly rapidly, while leaves are only available in sufficient quantities in a few localities. The use of expensive and concentrated manures like oil-cake, fish, and artificial fertilizers, has become general with irrigated crops and in intensive cultivation generally, but, so far, their profitable use has been restricted to such crops and such cultivation, and to people with sufficient resources to obtain them.

Night-soil is, however, a rich manure and is available everywhere either in the crude form or in the prepared condition as poudrette, but is hardly used owing very largely to the cultivators' scruples as to having anything to do with this material. In other highly peopled countries this is by no means the case. In Belgium it is very largely used, being carefully kept in *pucca* tanks and used as liquid manure. In Japan it is used for crops in a liquid condition, while in China its employment is all but absolutely general.

Even in Western India where it has been available in the form of poudrette and where intensive cultivation occurs in the immediate neighbourhood of a town, night-soil has gradually won its way to appreciation. At Poona, Kolhapur, Nasik, and other places where sugarcane is grown on a large scale, poudrette fetches a high price. But these cases are exceptional. In seacoast towns like Ratnagiri it has been usually thrown into the sea. In places like Broach, where no large irrigation cultivation exists, it has been burnt to prevent a nuisance. And generally it may be said that its utilization has hardly commenced in the Bombay Presidency.

In recent years, however, we have made efforts to utilize it in the neighbourhood of the smaller towns, and by experiments at the Jalgaon farm (East Khandesh) have shown its value so that the cultivators who formerly would not have anything to do with it now clamour for it at a cost of R. 1 per cartload. At Surat similar experiments have recently been made, and its use is now well known among the people. At Ratnagiri it has been used with success on rice, and at Broach and Dhulia on cotton, and an attempt is now being made to extend its use at a good many centres at least in Khandesh.

The sort of results obtainable with moderate dressings, in dry cultivation, is indicated by the following figures :—

Jowar (*Andropogon Sorghum*).—Experiment at Surat.

Dressing—40 cartloads of fresh night-soil per acre at a cost of Rs. 33.

	Yield per acre			
	Grain	Bhusa	Fodder	Total value
	lb.	lb.	lb.	Rs.
No manure	1,055	191	1,286	59
Night-soil	1,808	374	7,200	151
Increase	753	183	5,914	92

SORGHUM Without manure. | *SORGHUM* Under night-soil manure.

PLATE X

Cotton.—

(1) Experiment at Broach.

Dressing—70 cartloads of fresh night-soil per acre at a cost of Rs. 49.

	Yield per acre	
	Seed cotton	Total value
	lb.	Rs.
No manure	264	47
Night-soil	1,108	206
Increase	844	159

(2) Experiment at Jalgaon.

Dressing—34½ cartloads of fresh night-soil per acre at a cost of Rs. 36.

	Yield per acre	
	Seed cotton	Total value
	lb.	Rs.
No manure	213	33
Night-soil	988	152
Increase	775	119

Rice.—Experiment at Ratnagiri.

Dressing—3,000 lb. night-soil per acre at a cost of Rs. 1-8.

	Yield per acre		
	Grain	Straw	Total value
	lb.	lb.	Rs.
No manure	2,680	2,385	105
Night-soil	3,160	3,020	126
Increase	480	635	21

These results show that at present rates it is exceedingly profitable to use night-soil in the manner indicated.

It may also be noted that night-soil is a lasting manure. In an experiment carried on for the last twelve years at Surat (in the black cotton soil of Gujarat) upon a two-year rotation of cotton and *jowar*, to test the residual value of night-soil and farmyard manure, the following results were obtained. Night-soil was applied at the rate of 84½ cartloads and farmyard manure at the rate of 40 cartloads per acre in the year 1904-05 :—

Year	Night-soil plots			Farmyard manure plots		
	Jowar lb.	Straw lb.	Seed cotton lb.	Jowar lb.	Straw lb.	Seed cotton lb.
1904-05	2,723	7,888	.....	2,156	6,537	.....
*1905-06	.....	.....	52	.....	.....	161
1906-07	1,220	3,964	.....	931	1,876	.....
1907-08	.....	.....	898	.....	.....	638
1908-09	1,569	3,057	.....	769	1,484	.....
1909-10	.....	.....	789	.....	.....	465
1910-11	1,420	2,876	.....	1,067	1,813	.....
*1911-12	.....	.....	51	.....	.....	52
1912-13	588	1,635	.....	767	1,767	.....
1913-14	.....	.....	591	.....	.....	323
1914-15	992	1,961	.....	856	1,380	.....
1915-16	.....	.....	991	.....	.....	856
Average of six years	1,418	3,562	562	1,091	2,476	416

* These were years of very deficient rainfall.

The table clearly shows the residual effects of night-soil during a long period of years. Nowadays, a smaller dose is usually given at shorter intervals.

It is true that it is rather difficult to handle this stuff in the villages. In the municipal towns where it is generally carted out it is not at all difficult, and there is no reason why every town of any size should not arrange to demonstrate its use. Our experience is that it can be applied even in the crude state without any nuisance to speak of.

The method of application is as follows :—

The plot to which the crude night-soil is to be applied is thoroughly harrowed so that a layer of three inches of loose soil is produced all over the surface soon after the previous crop is harvested. Then wide, shallow furrows are made across the field by a heavy country harrow. This is prepared in the following manner.

The space between the two prongs of the harrow is tied up with ropes passed backward and forward so as to form a sloping surface against which the earth is heaped as it accumulates. So made, the furrows should be twenty inches wide with ridges on both sides three to four inches high and one foot wide at the base. The night-soil cart is driven slowly along with its opening over the furrow and the two wheels in the adjoining furrows on each side. One full cart, containing 1,500 lb. of night-soil, has been found to be sufficient for a length of ten chains, or 330 feet, and only alternate furrows are treated. The remaining furrows are given night-soil after about three days, when the night-soil in the previous furrows gets dry, so as to allow cart wheels to roll without being soiled by night-soil. After the material has been put on, the night-soil is covered as soon as possible with the earth from the side ridges, by men working behind the cart, to prevent the breeding of flies. After two weeks the whole is quite dry, and the field is cross-furrowed with the harrow prepared as before, and again in the original direction after another week. This repeated furrowing ensures the thorough mixing of the manure. After six weeks the whole field is harrowed both lengthwise and crosswise with a heavy harrow. In addition to all this the field should also be worked with a disc harrow in both directions.

To ensure success the following conditions are required :

(1) Before application of the manure the soil should be well harrowed, at least to a depth of three inches, so that the soil to that depth is loose and soft.

(2) The rainfall should be heavy in the first two months of the rainy season.

(3) The night-soil should be applied in the dry season so that it will get dry in the soil as soon after application as possible, allowing thorough mixing with the soil, and preventing the breeding of flies.

This is the method as applicable in the case of a small town. It is, however, necessary to work out some system to use the night-soil from the villages where the majority of the people live. If this can be done, it will improve village sanitation and at the same time it will introduce an inexhaustible source of excellent manure.

The present system in the villages is no system. It is most unsatisfactory from a sanitary point of view as it spoils the surroundings of the village and often contaminates the sources of drinking water. Prejudices will die out if a better system can be worked out. The man who will find out a suitable system will do incalculable good to the villages as well as to Indian agriculture.

Selected Articles.

THE WORLD'S COTTON SHORTAGE.*

BY

PROF. JOHN A. TODD.

III. THE ANGLO-EGYPTIAN SUDAN.

(Continued from page 120, Vol. XIII, Part I.)

GREAT expectations have been aroused as to the possibilities of the Sudan for cotton-growing, and while there is no doubt that these expectations will in the long run be justified, it is quite another matter to say whether the Sudan may be looked to for a solution of the immediate difficulty of the world's cotton shortage. That the Sudan may quite well produce *some day* the million bales of cotton which the world requires so pressingly to-day is very likely; but the doubtful factor in the situation is time. For many reasons the development of the Sudan must be a matter of time; and time is the crux of the whole problem of the cotton supply to-day. In the first place, it must be realized that the Sudan is an enormous country with a geographical area of over a million square miles. For comparison it may be mentioned that the total area of the American cotton belt is about 700,000, and that of the British Isles about 120,000 square miles. But such comparisons are entirely misleading in another way. The cultivated area of the Sudan to-day consists of only a few relatively small strips or patches separated by enormous tracts of desert, or in the south of wild tropical vegetation like the Sudd. These waste lands of to-day are not necessarily uncultivable, but they must for a long time to come

* Reproduced from the *African World*, dated 8th September and 6th October, 1917.

lack the necessary conditions of cultivation – namely, water (except in the south), labour, and communications. This enormous country stretches from north to south through no less than seventeen degrees of latitude, and possesses a wide variety of climatic conditions from the practically rainless areas of the Red Sea littoral to the regions of tropical rainfall on the borders of Uganda and the Belgian Congo. It is thus impossible to generalize about the Sudan as a cotton-growing country. There are, for example, four entirely separate areas in which cotton is at present grown, but the conditions of these areas vary greatly in respect of climate, labour supply, and communications, which are the main factors in the development of a cotton country. Thus the bulk of the cotton actually produced in the Sudan so far comes from the Tokar District, near the Red Sea coast. There the conditions are entirely based on irrigation, for the rainfall is trifling. The water supply comes from the river Baraka, which comes down in flood once a year from the Abyssinian mountains, as the Blue Nile does into Egypt. Unfortunately, this supply is subject to no natural control; its channel varies from year to year, and the volume of the supply is unreliable. So far it has not yet been found possible to find the money for the artificial control works which would render cultivation certain over a much larger area than at present. As things are, the native cultivators cannot be expected to risk much labour or capital in preparing the land for the crop until they see whether the water is coming their way, and the effect may be summarized in the single fact that the yield of lint cotton per acre is only about 100 lb., as against an average of 400 or 500 in Egypt and in other parts of the Sudan. The largest area which has so far been under cotton in any one year was something over 50,000 *feddans* (acres), but this could be increased by about one-half if the necessary control works could be put in hand.

The labour supply in Tokar is satisfactory, being largely recruited by the migration of pilgrims from all parts of Western and Central Africa, who pass through this district on their way to Arabia for the pilgrimage, and put in a season or two here and earn enough money to carry them over the next stage.

The general character of the cotton grown is excellent. It is entirely Egyptian, and the most striking feature of the district is the way in which the Government, by careful control of the native handling of the crop at every stage from seed selection to the picking and grading of the crop, has secured and maintained a high level of quality in the product as a whole.

Another great hindrance to the development of this area is the cost of transport. The crop has to be carried on camel-back to the port of Trinkitat, from which it goes by small native boats to Suakin or Port Sudan. A railway from Tokar to Port Sudan has long been under consideration, and its construction would greatly aid the development of the district. So far the maximum crop has been that of 1914-15*—*viz.*, 70,000 *kantars* (of 100 lb.), or, say, 17,500 bales of 400 lb., which, by the way, is the usual bale weight in all our African possessions outside of Egypt.

The next cotton district of importance is that of Kassala, which lies inland from Tokar on the borders of Eritrea (Italian Somaliland). Here the climatic conditions are similar to those in Tokar, the water supply being from the river Gash, another summer torrent which comes down in flood-time from the mountains, but loses itself completely in the deserts below, and as a matter of fact never reaches the Nile tributary, the Atbara, to whose basin it belongs. The greatest difficulty here is again the question of transport. At present the place is about a fortnight's journey on camel-back from the nearest station on the Port Sudan-Khartoum line, and no great development can be expected until direct railway communication is provided. This again presents no great difficulties except financial. In the meantime the record crop is under 500 bales ; but it is said that there are 120,000 acres of good land available for cotton-growing if irrigation were provided, as it could be, so that a crop of nearer 100,000 bales should be possible. It must, however, be a long time before such possibilities come within sight. The cotton grown is mostly of Egyptian quality. Coming still further inland to the Nile Valley, there are on the Nile itself, north

* 1916-17 figures are not yet available.

of Khartoum, several more or less isolated districts where cotton has already been grown with success, such as Zeidab, which lies nearly 200 miles north of Khartoum. The prospects here seemed at first excellent and very good results were obtained, but an unfortunate element of uncertainty entered into the yield owing to the danger of very cold nights during the cotton season, which may do such damage as to reduce the amount of a year's crop in a few nights from a maximum to a minimum. The result is that the crop is extremely speculative, and it is doubtful whether cotton-growing here will for some time to come be worth spending money on when there are other areas awaiting development which do not suffer from this handicap. The cost of transport by rail or river to Egypt and thence by sea to England is also a heavy handicap.

The Nile Valley areas north of Khartoum have, however, recently been entirely eclipsed by the brilliant prospects opened up for cotton development in the great plain known as the Gezira. lying between the Blue and White Niles south of Khartoum. Before the war this district had been surveyed by representatives of the British Cotton Growing Association, who brought home glowing accounts of its possibilities. There can be no question that this district, which is of enormous size, about 4,000,000 acres, or more than twice the whole acreage under cotton in Egypt before the war, will one day be a cotton-growing area of the first value. It only requires water to make it equal to Egypt in productivity, and yields of over 500 lb. an acre of good Egyptian cotton have been obtained. Before the war all arrangements had been made for its development, which meant large irrigation works on the Blue Nile, and the British Government had agreed to guarantee the interest on a loan of £3,000,000 to be raised by the Sudan Government for development purposes in this and other areas. Unfortunately, the war stopped all these schemes, and they have only recently been taken up again in a very halting way, with the result that three precious years have been lost. Perhaps, however, the time has not been altogether lost, for in the meantime the Sudan Plantations Syndicate, which is working the scheme in co-operation with the Sudan Government and the

British Cotton Growing Association, has been carrying on work on a scale which can hardly be described otherwise than experimental, but which has given excellent results. The area under cotton is now over 2,000 acres, and could be very rapidly extended if the necessary irrigation facilities were available. Transport is comparatively easy, for the main line of the Sudan Government railways runs through the district, and will carry the cotton at not too great a cost to Port Sudan; for the cotton is of Egyptian quality, and therefore of high value which will stand a relatively heavy freight.

But the great difficulty at present in the Sudan, and indeed the controlling factor in the development of the country as a whole, and of cotton-growing in particular, is the labour supply. The population of the Sudan was almost wiped out by the wars of the Mahdi and the Khalifa, and in 1898 it was said to be only about two millions as against previous estimates of over ten millions. Under the new conditions of peace and prosperity it is, of course, increasing again with Oriental rapidity; but it is still far short of the number required for the full development of the country, and for many years to come it will be a case of *festina lente*. The three years of the war have meant no check on this increase in the Sudan which has been practically out of the war, and if now the necessary development works are pushed on energetically these three years may prove to have been no real loss to the ultimate development of the country.

But this only serves to emphasize the main fact of the situation in the Sudan, which is the need of time. The Gezira will some day be one of the largest areas for the production of fine cotton in the world, but that day is still a long way ahead, and it is very difficult to guess when the Gezira crop will even touch 100,000 bales. Certainly not for some years yet, perhaps five or ten from the time when the irrigation works are completed, and these will take two or three years from the time when the money is found and the work seriously put in hand. When, then, will that be?

Finally, there are great possibilities of cotton-growing under entirely different conditions in that part of the Sudan which lies far south of the areas already described. In the Southern Sudan,

in the Valley of the Nile, there are enormous areas where the rainfall is tropical and the whole country a mass of luxuriant vegetation. Here rain-grown cotton of good quality and about American character has already been grown in considerable quantity, though the maximum crop has probably not yet exceeded 5,000 bales ; and it is possible that huge areas may some day be opened up here which could supply unknown quantities of good average cotton. But that development must be in a rather distant future. The development of the Sudan will take time and enormous sums of money, and the labour supply can only increase gradually. To attempt to rush matters would be to court failure, for nothing could do more harm to the real prosperity of the Sudan than a sudden demand for labour in excess of the supply, which would artificially force wages up to a level that would render cotton-growing impossible, as it is rapidly doing in America.

To sum up, then, the Sudan is a country of unlimited possibilities for the future supply of cotton, and it may well become in the future the main source of our supply of fine cotton. But its development cannot be forced. The irrigation and other development works which the Government has already sanctioned must be pushed on with energy, and the results will certainly be such as to cover very handsomely the cost of these works and the further investment of capital which will have to be made by the pioneers of the industry.

But the cotton industry must understand that the relief which they so urgently require in the present shortage must not be expected from the Sudan within any time which they can contemplate with equanimity at the present juncture. The Sudan may in course of time make up for the shortage of the Egyptian crop ; but it would be foolish to imagine that the great desideratum of a million bales of " bread-and-butter " cotton can be supplied by the Sudan, at least within the life-time of the present generation.

IV. BRITISH WEST AFRICA.

In the last article it was pointed out that the Sudan may reasonably be expected to become in course of time the source of a

very large new supply of fine cotton. In the same way there is every reason to hope that West Africa will some day be able to supply a large part of the requirements of Lancashire in ordinary "bread-and-butter" cotton. But, as in the case of the Sudan, it is quite another matter to say when. As has been frequently pointed out in these articles, what the world wants to-day is a cumulative increase of about a million bales per annum of cotton round about an inch staple. West Africa is still, unfortunately, a very long way from producing that quantity, though there is no reason why she should not do so some day.

British West Africa again, like the Sudan, is an enormous country, with a total area of about 350,000 square miles, but a much larger proportion of the total area is cultivable than in the former case. Not all of it, however, could grow cotton. Along the coast is a low-lying belt of mangrove swamps of deltaic character, where cotton is out of the question. Beyond this lies the great forest belt, which, as it stands, yields so many valuable products that there can be at present little prospect of its being profitable to convert any material part of it to cotton-growing. The great cotton area is the hinterland of park-like country beyond the palm-belt, and it is estimated that, making every allowance for the amount of land that will always be required for foodstuffs, there should be an area of about 25,000,000 acres here available for cotton. A crop of five or six million bales of cotton seems, therefore, not impossible, but that is a very long way beyond the present maximum production.

In estimating the present production of the country, however, one may very easily be misled by taking merely the export figures, such as those given below from the reports of the British Cotton Growing Association. The fact is that West Africa has been a cotton-growing country for many centuries, and that the natives have all along been growing and manufacturing much of the cotton which supplies their own needs. Native cotton cloths of quite good design and character have long been produced in the district, and have established their market throughout the whole of Northern Africa as far north as the Mediterranean. It would probably be a safe estimate of the amount of this native crop to put it at

100,000 bales per annum. Herein lies the essence of the problem which the British Cotton Growing Association have had to face in West Africa, and which makes the situation there distinctly different from that of other parts of the Continent. It is not a question of teaching the natives to grow cotton. The problem is rather to show that it will pay them to grow a better variety of cotton, and export it, taking payment in the long run in goods of European manufacture. Again, there are in all parts of West Africa where cotton could be grown so many other products which compete with cotton that it is throughout a question of economics whether cotton or these other crops will pay the native producer best. The labour supply of the country is ample—the population was estimated some years ago at about 18,000,000—and well habituated to cotton-growing. But the native is, in his own way, very shrewd, and quite capable of calculating which crop will best repay him for the trouble of growing it. The Association has practically from the first gone on the lines of making the native cultivators their own masters, instead of trying to develop large European-owned plantations, with the natives as wage-paid labourers.

Under these conditions, the main factor in the problem of developing a large export crop of cotton is that of price, which again becomes largely a question of cost of transport. The price which the Association can offer to the native producer for his seed cotton—and they have very wisely always gone on the principle of offering the highest price they could afford to pay—depends on (1) the relative yield of lint cotton and seed from the seed cotton, and (2) the cost of getting the various products to market. Practically speaking, the second of these problems has been solved so far as cotton is concerned (but not seed), for the internal communications of West Africa are now, comparatively speaking, quite good. By rail and river, communication is now possible over very large parts of the country and long distances from the coast, and though, of course, an unlimited quantity of money could be spent on further development of the railways, and especially of roads in view of the possibilities of motor transport, it may be said that the lack of communications is not the worst difficulty to be solved.

The greatest difficulty now is due to the peculiar character of the indigenous types of cotton. These are, on the whole, fairly satisfactory, but they have one serious defect. The "ginning out-turn," or percentage of lint cotton obtainable from the seed cotton, is distinctly low, only about 27 per cent., as against over 30 in America and Egypt, and as high as 40 and even 50 in the case of certain varieties in India. When the Association buys the seed cotton at, say, the pre-war rate of $1\frac{1}{8}d.$ per lb. it is really paying over $4d.$ per lb. of lint, and when to this are added all the costs of ginning, baling, forwarding to the coast, and shipping to Liverpool, it means a cost to the Association of nearly $7d.$ per lb. of lint delivered in Liverpool. Again, owing to the cost of transport, it is almost impossible for the Association to make anything out of the seed, which, as a matter of fact, they have used to make producer gas for the power required at their ginneries. Now, if the natives could be induced to grow a better variety of cotton with a slightly higher ginning out-turn, it would enable the Association to pay them a very much higher price per lb. of seed cotton, especially if the new variety also possessed the advantage of a slightly longer staple.

It is along these lines, therefore, that the efforts of the Association have been mostly directed for many years back, and it is gratifying to know that they are apparently at last in sight of success, thanks to the untiring energy of the Director of Agriculture, Mr. P. H. Lamb, for during the last few years a new variety has been put out in Northern Nigeria, which is apparently catching hold very widely, especially in the Zaria District. For this variety the Association is able to pay $1\frac{3}{4}d.$ per lb. instead of $1\frac{3}{8}d.$ for the native types, and the natives seem to find this difference quite enough to change their whole attitude to cotton-growing, especially as the new type gives a better yield per acre. During the last two years fairly large quantities of this cotton have been coming in; in 1916-17 it should have reached 2,000 bales, but a disastrous "Harmattan" reduced the yield to about 500 bales. But the seed from this should be sufficient to produce several thousand bales in the coming season. The total purchases in Northern Nigeria in 1916 established the

record figure of 10,746 bales, or more than half of the whole crop of the country. It is unfortunate that this year, owing to climatic conditions, the figures are not likely to be so good again, and this points to the chief drawback of the country as far as climate is concerned, *viz.*, the Harmattan winds. These are hot, sultry winds blowing from the interior of Africa towards the coast. They are loaded with clouds of reddish dust from the desert, and are characterized by extreme dryness. No dew falls while the Harmattan lasts, so that vegetation is withered up, and a bad spell of these winds may reduce the crop to a fraction of what it might otherwise have been. This introduces an undesirable element of uncertainty into the economic yield of the crop, and that is always very much against the struggle of cotton in competition with other crops the yield of which, though perhaps smaller, is more sure. Here, again, however, it is hoped that the new varieties may prove better able to withstand damage, so that their chances of success are still further heightened.

There seems reason to believe, therefore, that the corner has been turned in Northern Nigeria, and the development of large cotton areas there and in other parts of the country is only a question of time. Unfortunately, time is just what we cannot spare at present, and it must be realized that we cannot look to Nigeria for a large share of the desired million bales within any brief period. Five or ten years may see Nigeria thoroughly established as a serious contributor to the world's supply, but it must be remembered that the new supply will bring a new demand for cotton goods in payment. Those who wish to see the British Empire self-contained as regards its raw cotton supplies must be prepared to spend money very lavishly on countries such as West Africa, where cotton-growing is now really past the pioneer stage. The industry owes a great debt of gratitude to the British Cotton Growing Association for all that it has done to bring Nigeria through that stage, but it must not be imagined that a semi-philanthropic association with a capital of a paltry £500,000 spread over all the possible cotton-growing countries in the British Empire is a final attempt to meet the need of a large new supply of cotton. It is millions, not

thousands, that are wanted in Africa, and they are wanted to-day, not "after the war."

APPROXIMATE ESTIMATE OF COTTON GROWN IN NEW FIELDS IN WEST AFRICA, 1910—17.
(In bales of 400 lb.)

—	1910	1911	1912	1913	1914	1915	1916	1917
Gold Coast	100	100	120	100	100	100	100	suspended
Lagos	5,900	5,800	8,900	14,000	13,600	6,200	9,200	9,000 *
Southern Nigeria ...	300	300	270	200	150	100	100	100 *
Northern Nigeria ...	400	600	2,600	2,000	1,000	1,200	10,800	5,000 *
TOTAL ...	6,700	6,800	11,890	16,300	14,850	7,600	20,300	14,100 *

* Estimates.

FACTORS IN AGRICULTURAL PROGRESS.*

BY

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EVERY businessman knows full well that the success of any manufacturing enterprise depends on economic considerations as much as it does on technical skill. The projector of a new industrial concern will, accordingly, arrange the scope and magnitude of his enterprise in accordance with general business principles and with the peculiar economic facts of the case. The supply of raw material must be adequate and the market secure; the industry must be of sufficient size to bear the cost of efficient management, the engines large enough to supply the requisite power, the machinery efficient, the buildings properly designed, and the working capital adequate; by-products must be fully utilized, and there must be no avoidable waste of material or time. When the factory has been suitably located, designed, equipped, and financed, the primary requirements for success will have been secured, and the outcome will then depend on capable management and technical skill.

In agriculture it is, from the nature of the case, impossible that the same precision of organization can be secured as in the case of industrial enterprise; but it is certain, none the less, that success in agriculture depends largely on the factors similar to those already enumerated. Are the size and distribution of the holding suitable? Is it properly equipped and stocked? These are questions that must be answered before success or failure can be attributed to the personal characteristics and skill of the farmer.

* Reprinted from the *Mysore Economic Journal*, Vol. III, No. 9.

To revert to the analogy of the factory. Suppose that the directors of a cotton mill in Bombay were to call in a weaving expert to advise them as to what was wrong with their system of weaving, and the expert were to find that the mill was situated at Dadar, the offices in the Fort, and the godowns at Colaba, that the engines were much too large for the work that they had to do, the number of looms too small to turn out produce sufficient to support the cost of the management, and the working capital inadequate. In such a case the weaving expert would assuredly say, "First get all your buildings conveniently situated in one place, increase the number of your looms, and put your finances in order, and then call me in for technical advice." This is the problem that the Agricultural Department has so frequently to face when called in to advise cultivators. It is often the organization which is wrong, not the technical skill; and though there is usually ample room for improvement in the latter, many obvious improvements which might otherwise be suggested are found to be hopelessly blocked by the economic circumstances. There are many physical obstacles for the chemist, the botanist, and the engineer to surmount, but the value of their assistance must be seriously discounted where the obstacles which dominate the situation are economic; and this state of affairs must continue to exist until the economic difficulties are overcome.

By the above remarks it is not intended to suggest that agricultural salvation lies in capitalistic farming on a large scale. In some countries and in some branches of agriculture good financial results are obtained in that way; but the system of Hindu Law aims at a wide distribution of the land amongst a large proportion of the population, and the spirit of Indian agriculture indicates the peasant farmer as its ideal. With this latter view modern European opinion is in agreement, and many countries, in which the peasant farms of olden times have been merged in large estates, are now trying to call into existence a new class of peasant farmers and to revert to the old system—but with a difference; and the difference is indicated by the fact that the present aim in such countries is not merely to create peasant holdings, but to create suitably sized and

suitably situated peasant holdings, to equip them with adequate stock and capital, and to provide for their maintenance intact in that condition. It is well known how far the subdivision of holdings has been pushed in India, how large a proportion of the cultivators struggle to support life on holdings too small to provide a comfortable living by existing methods and too much fragmented to admit of such development as alone would compensate for their small size. There is no need to enlarge on the existing situation. What then would be the ideal condition ? Let us suppose the plain of Gujarat or the valleys of the Deccan divided up into compact holdings of twenty to forty acres, each fitted with its homestead, cattle-shed, storehouse, and well, the houses perhaps grouped into hamlets with space sufficient to allow each man plenty of elbow room, without isolating each family in such a way as to destroy social life or render co-operative and communal action impossible, the land levelled and embanked, the holdings fenced, and each equipped with effective implements and one or more pairs of good bullocks. A distant ideal, it may be said ; but still one which many countries have set before themselves and are realizing by slow degrees.

No one would attempt to force all the holdings of a country into one standard pattern. There is room and necessity for diversity and advantages in variety ; but in any tract it is possible to formulate rough limits of area and equipment calculated to admit of the realization of optimum results ; and it is desirable that these limits should be clearly recognized and that sustained efforts should be made to secure for a large proportion of the farmers conditions which are compatible with successful farming and effective development.

It is not proposed to discuss the method by which such change should be effected, since the question is a large one and bristles with difficulties ; all that is here intended is to emphasize the primary and fundamental necessity of the agricultural situation in the Bombay Presidency. The change suggested would inevitably bring about permanent improvements now so badly needed, induce progress in agricultural practice and, by stimulating the activities of the farmers, would effect many profitable modifications in the

existing system of farming. It is, after all, the intelligent and industrious activity of the farmer which is the mainspring of production, and it is by stimulating and using to the full this agency that all improvements must be effected. The farmer has little opportunity of wasting anything, but there is one thing that he does waste lavishly—and that is his time. Once get him out of the vicious economic circle which now numbs his activities, and the results will soon be apparent.

Mention has been made of possible changes in the system of production. The thing which strikes most observers is that the Indian cultivator trusts too much to a single crop, and that he has few subsidiary sources of industry or income. With cotton at its present price the one object of the cultivator in the cotton tracts is to grow as much cotton as possible, and in this he is right; but it does not follow that twenty acres of ill-tilled and ill-manured land will give as much out-turn as ten or fifteen acres of land better tilled and better manured; and in most localities it will be found that with adequate organization the breeding and rearing of live-stock, milk production, or poultry raising offer opportunities from which most cultivators are now debarred by the existing conditions of congested villages and scattered holdings, even though the supply of fodder, the range of pasture, and the accessibility of markets may be favourable.

To turn from general economic conditions to more detailed technical questions. What are the factors in successful crop production? Soil, moisture, and temperature are the primary factors, and human effort can do nothing to affect the temperature, the rainfall, or the geological formation; but by embanking the fields and checking erosion the depth and quality of the soil may be improved, by suitable manuring and rotations its chemical and physical qualities may be modified, while irrigation and good tillage will compensate for the deficiencies of the rainfall. It is by such methods that the cultivator may become the master of his fate rather than the slave of circumstances.

Some years ago enquiries were made in Europe regarding the process of agriculture during the past century, and the relative

importance of the factors which had produced the results. Statistics show that during the past century in Europe the out-turn of wheat and other cereals has been doubled, and experts in various countries were asked to indicate the proportion of this 100 per cent. increase that could be assigned to each of the following factors, *viz* :—

(1) Improved seed.
(2) Improved and increased manures.
(3) Better rotations.
(4) Better tillage.

The experts consulted generally agreed that out-turns had increased from 50 to 100 per cent. during the past century, and in some cases it was declared that the out-turn had been trebled. The causes of this improvement were assigned as follows, *viz.* :—

	England per cent.	Germany per cent.	France per cent.
Improved seed	10	15	5 to 20
Improved manure	Considerable	50	50 to 70
Improved rotation	Little except indirect	10	...
Improved cultivation ...	Most of all	25	15 to 30

It will be noticed that manure secures the first place amongst the causes that have contributed to increased yields, and under the heading of manure is included not only artificial manure, but in an even greater measure the increased supply of farmyard manure due to the increased number of live-stock kept, and its increased value due to the concentrated foods that are now fed to cattle. Next in order comes improved cultivation, which secures the first place in England and the second place in Germany and France. It may be noted that in England, where the first place is assigned to it, the term cultivation is taken to include drainage operations. On the other hand, it is noted that in many cases where the degree of cultivation has not been improved the cost of the operations has been cheapened, and also that without good cultivation nothing like the full effects of the manure could be secured. Improved seed comes in a bad third, and it is noted that even such improvement can be secured by the use of good seed only when the cultivation and the manuring are adequate. It must be recognized, however, that the difference between the cost of using good or bad seed will amount to comparatively little per acre, and that if a

10 or 15 per cent. increase in produce can be obtained in this way there is no excuse for not securing it. Improved rotations are held to have produced little direct result, but have rendered the wasteful practice of the bare fallow unnecessary, and by adding greatly to the supply of fodder crops have enabled the farmers to keep more live-stock, and so have been the indirect cause of the increase in manure.

Now the opinions recorded above cannot, of course, be taken as a general guide in India with its varied conditions, but there are some tracts to which they would apply with a fair degree of accuracy, and they have a bearing on the question of agricultural improvement almost everywhere. In the arid tracts of India where moisture is the limiting factor in crop production, irrigation is the prime necessity, and by this means crop out-turns can be doubled and other crops of ten times the value grown. In such tracts the question of manure has little importance in the absence of irrigation: but, given irrigation, manure becomes of vital importance. Practically everywhere there is a vast field for improved tillage which is now very defective; and wherever the rainfall is fairly abundant the supply of manure needs increasing. In the matter of seed there is certainly good scope for progress with a crop like cotton, but in the case of crops like *jowar* (*Sorghum*) and *bajri* (*Pennisetum typhoideum*) the prospects of material improvement in this direction seem to be much less hopeful. Where the land is sloping and heavy rainstorms occur, a system of field embankments which will regulate the surface water and check erosion and scouring is very necessary and produces marked results.

If an opinion were asked for as to the prospects of improvement and the methods to secure it with reference to any definite tract, it might be possible to hazard such opinions as the following, *viz.*:—

I. Improved out-turn possible on a typical sloping cotton field in the neighbourhood of Dharwar (Southern Maratha country) 100 per cent.

Factors	Per cent.
Seed	20
Cultivation	30
Field embankments	20
Manure	30

II. Improved out-turn possible on a typical cotton field in the neighbourhood of Surat (Gujarat) 60 per cent.

Factors	Per cent.
Seed	20
Cultivation	20
Manure	20

Taking the Bombay Presidency as a whole, improved cultivation stands easily first in the factors of improvement, and this connotes better implements and better cattle. The cattle are a very important consideration since they supply both the motive power for the tillage operations and the manure for the fields. Any system of farming which will enable the cultivator to breed good cattle at a profit and to maintain his work bullocks without undue cost, will do much to solve the primary difficulties of the situation, and this is very largely dependent on the organization of the land holdings, a consideration which brings us back to the point from which we started.

DEVELOPMENT OF BANKING AND THRIFT IN INDIA.*

BY

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Of the many problems connected with India that have come to the fore during the course of the war, none is so important, and perhaps none is so complex, as the question of the economic or material development of the country. Proud as we Indians are of the share that India is taking in the great struggle, it is still a humiliation to many of us that the contribution in men and material has not been infinitely larger than we have been able to afford. It is the earnest hope of all of us that if ever in the future India is called upon to defend and conserve her liberties from external aggression, India's own effort, apart from the assistance that she will receive from the United Kingdom and other units of the Empire, will be more commensurate with her history, the immensity of her population, and the vastness of her potential wealth. In order to prepare for such a contingency, it is absolutely necessary that all possible measures should be adopted for the ordered organization of our manifold resources.

Even if we leave the problem of defence entirely out of account, there are other and urgent reasons for an immediate and sustained effort to increase the income of the people of India. Our poverty is now fully recognized. As Mr. Moreland has very clearly put it in an article in the current number of the *Quarterly Review*, "it is a

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* A paper read at a meeting of the Indian Section of the Royal Society of Arts, London, on 17th May, 1917. Reprinted from the *Journal of the Society of Arts*, July 6th, 1917.

matter of common knowledge that the standard of life in India is undesirably low; that, while the masses of the people are provided with the necessities of a bare existence, they are in far too many cases badly housed and badly clothed, badly doctored and badly taught, often overworked and often underfed; and that the present income of the country, even if it were equitably distributed, would not suffice to provide the population with even the most indispensable elements of a reasonable life." Our main dependence for several generations now has been on our agriculture, but the recent remarkable applications of science to the agriculture of all the older countries of the world, together with the opening out of the extensive prairies of new countries, has already threatened our position in the world market for agricultural goods, and the problem is likely to be far more acute in the near future. In industries, the revolution in processes of manufacture and organization, that has been in progress in the western world for more than a century, has wrested from us the pre-eminence in certain commodities that was ours from the early days of the Roman Empire. Our industries need development, not only to replace what has decayed, but also to supplement and reinforce our agriculture. Altogether, humanity in India has to be raised to a much higher level of efficiency and well-being than what we have so far been accustomed to.

There is one common factor in the various departments of economic development to which I have just referred. Capital is needed for all of them. It will be readily conceded that neither education nor sanitation can be developed without the laying out of immense sums of money which will not begin to yield any tangible returns for almost a generation. A more immediate remuneration is likely in other necessary directions of State activity. Means of communication and transport will absorb very large funds for a long time to come. Similarly, more money must be spent on the expansion of irrigation in tracts like Oudh, while the full exploitation of our forests can no longer be deferred without serious detriment to the national welfare. Turning to the sphere of private enterprise, capital is the primary necessity for the development of industries, and here also large or immediate returns cannot be looked for.

Additional capital is necessary for agriculture as it is for industries. A query that has often been put to me is, whether we can forecast the period of time that will be required to make our co-operative agriculturists self-dependent and self-contained with respect to capital. Frankly speaking, I cannot foresee that this condition will ever be attained. It is true that, as a result of the thrift inculcated by co-operation, the peasants will, within a measurable period of time, amass capital equal in amount to what they use now. But the capital that can be profitably utilized in their agriculture, even in the present stage of science, is almost infinitely larger than what is actually available, and we must not forget that science is progressive. It has also to be borne in mind that co-operation, while it teaches thrift, also enlightens the mind of the peasant and makes him desirous and anxious to adopt new and improved methods which involve the investment of larger capital. A year ago the number of members in agricultural credit societies in India was over seven hundred thousand, and their total capital was a little under three and a half million pounds sterling. This gives an average capital of slightly less than five pounds per member. I think it will be no exaggeration to state that, with proper training and organization, the capital required will come up to at least thirty pounds per member on the average. If the number of agriculturist families in India be reckoned as, roughly, forty millions, the funds required for financing agricultural processes alone amount to twelve hundred millions sterling. It is not possible to hazard even conjectural guesses regarding the outlay that will be needed for industrial and commercial development, or for such communal activities as education or sanitation.

It is my object to-day to draw your attention to this important aspect of the very large question of the full economic development of India. Until recently, we had a comfortable feeling that the organization of our material resources might safely proceed along lines of slow and steady growth, and that, if sufficient capital for the purpose were not readily available or forthcoming in the country itself, it could at a price be obtained from the richer and more highly developed countries of the world. The far-reaching incidence of the

war has rudely dispelled both these illusions. It is now universally realized that in the interests of India herself, and in the interests of the Empire, her economic progress should not be left to slow natural forces, and that the pace must be accelerated by well-conceived measures on the part of the State and of the people. With regard to the supply of capital from non-Indian sources, it is now abundantly clear that even if legislation does not actually prohibit, for a considerable time after the war, the export of capital from the richer countries of the world, their internal requirements will leave only a very small surplus to be shared between India and other undeveloped lands. The money that we may be able to borrow in London after the war will command a price which we cannot pay without seriously handicapping ourselves, and although I am not in a position to speak with confidence on this point, I entertain grave doubts whether we shall be able to borrow here anything approaching the amount that we shall actually need immediately after the war is over."

The conclusion is irresistible that India must in the main rely on herself and look to her own resources for the capital required for her development. To avoid any misunderstanding, I may mention that this is a view which, so far as I am aware, has never been sought to be imposed on India from without, but is only in accordance with the new ideas of true self-help that have been generated of late in our country. The question now arises: What are our available resources for the capital that is needed? The answer naturally suggests itself—India should unlock her hoards of the precious metals. From the time of Pliny she has imported large, though varying, quantities of gold and silver. In his work on "Indian Currency and Finance," Mr. J. M. Keynes states that "during the sixty years (preceding 1913) India is supposed to have absorbed, in addition to her previous accumulations, more than three hundred millions sterling of gold (apart from enormous quantities of silver)" (p. 100). Where all this gold and silver have disappeared is one of the puzzles for the economic historian of India. I do not pretend to be ready with a solution; but, apart from the partial explanation furnished by Mr. Keynes himself (p. 154), *viz.*, that "the recorded statistics of trade overland show a large balance against India, which is probably met

by an unrecorded export of gold, silver bullion and rupees," we must not forget that down to the middle of the eighteenth century India was periodically visited by bands of invaders who, in the majority of cases, left almost as speedily as they came after gathering extensive spoils in gold, precious stones, and other treasure. Also down to the beginning of the nineteenth century the pagoda tree of India was shaken for its fruit by numerous European adventurers. The costly industrial arts of India, some of which survive to the present day, must also have consumed large quantities of the precious metals. I do not deny that the gold and silver jewellery even now owned by our women will in the aggregate reach large dimensions, and I also believe that here and there individuals possess comparatively big hoards of gold and silver, while many similar and smaller hoards secreted away during the centuries of anarchy and insecurity now lie unknown to all and are permanently irrecoverable. But apart from the jewellery of the women, I am rather sceptical about the existence among the general population of any hoards of substantial value, at least in the provinces with which I am familiar. I do not wish to imply that the average peasant in India does not possess a few rupees tucked away in the roof of his hut or some other equally likely spot; and, if each person in India can be assumed to possess in the average five rupees in cash, we get the respectable sum of 100 millions sterling.

Law and order, combined with opportunities of sound and profitable investment, are, as we shall presently see, bringing to light the hidden hoards of India, and the process is likely to be considerably accelerated in the near future. Hoarding, however, as much as saving for useful employment, is a habit that takes long to instil as also to eradicate. We shall certainly be better off than we are at present when the instinct of hoarding, either in the shape of coin or bullion or in the form of jewellery, is completely overcome; but personally I do not consider that all our needs will be thereby satisfied. That is why I wish to see inaugurated as soon as possible an active and sustained campaign of national thrift through the length and breadth of the country. It is fortunate that the war loan now under flotation in India is practically originating a movement of

national thrift, and it is to be sincerely hoped that the organizations called into being for this immediate object will be widespread and efficient, and that they will be maintained so long as there is need for capital for the purposes of national development.

Thrift is not an unknown virtue in India, and banking in its different aspects is by no means an exotic transplanted from the West. Students of our ancient civilization are familiar with the numerous references in contemporary literature to the prevailing custom of deposits with bankers, the use of promissory notes, and the issue of letters of credit and bills of exchange for the purposes of internal and external commerce. The injunctions of Hindu law-givers on the subject of usury afford a clear indication of the practice of money-lending by the State and by private individuals. (For authorities, *vide* McCrindle's "Ancient India," p. 69; Rhys David's "Buddhist India," p. 101; Barnett's "Antiquities of India," p. 130.) References to *sahas*, or bankers, are to be noted in the early Muslim annalists. Indeed, the extensive commerce that was carried on in the Middle Ages within India itself and with countries outside would have been impossible without fairly well-developed banking facilities. In the seventeenth and eighteenth centuries the East India Company made full use of the indigenous banking agencies, and even at the present day much of the internal commerce of the country is financed by Indian bankers, though it must be admitted that joint-stock banks are fast encroaching on their domain, and their methods are not sufficiently elastic for modern requirements. It is also exceedingly doubtful whether Indian banking at any time financed industry or national development. But even in Europe the functions of banking were, until recently, strictly limited to providing for the requirements of commerce and the pressing necessities of the State. It is true that a substantial proportion of the capital used by Indian bankers has been owned by themselves, but it is equally true that they have freely received deposits from their clients and customers. A portion of such deposits is held at call and consequently free of interest, but otherwise interest has always been allowed on deposits confided with Indian bankers.

Premising, therefore, that the habit of saving for profitable employment is not contrary to the traditions of the Indian people, and that consequently there should be no insuperable difficulties in resuscitating this instinct in a more active and more widely-diffused form than in former days, we may examine the inducements for thrift that exist in India at the present moment. About six years ago Mr. Reginald Murray contributed to this Society an excellent and authoritative paper on "Banking in India," in which he furnished an account of our modern banking system. Fuller histories will be found in the standard works of Mr. Brunyate and Mr. Keynes, and in the Blue-books annually issued by the Government. I shall, therefore, refer very briefly to the types of banking that are to be met with in India. We have first of all the three Presidency Banks, which enjoy certain special privileges accorded by the Government in return for services rendered. The capital of these three banks, which stood in 1880 at £2·33 millions, had risen in 1914 to only £2·5 millions; but the reserves during the corresponding period had increased from £0·4 million to over £2·5 millions. The expansion in business has been even more remarkable. Non-public deposits, which stood at only £5·7 millions in 1880, were nearly £27 millions in 1914. The next class is that of the Exchange Banks with head offices oustside India, some transacting the greater part of their business in India, while others have merely agencies in India. It is, therefore, unnecessary to quote figures of their capital and reserves, but it is worth noting that the deposits in India increased during our period from £2·15 millions to £20 millions. We now turn to the joint-stock banks with head offices located in India. The management of several of the larger banks of this type is purely British, but I believe that a substantial portion of the capital of such banks is owned by residents of India. In 1880 there were only three joint-stock banks with a capital and reserve of over thirty thousand pounds each. In 1914 the number was seventeen, and the aggregate capital and reserves of these larger banks had risen from £0·14 million in 1880 to £2·6 millions in 1914. In the same period deposits increased from £0·4 million to £11·4 millions. As a matter of fact, in 1912 the deposits had reached the figure of £18·2 millions. The banking crisis of

1913 and the disturbance caused by the war were responsible for the decrease. In addition to these larger banks there were, in 1914, twenty-five joint-stock banks with a capital ranging between six thousand and thirty thousand pounds, which held in the aggregate £4 millions in capital and reserves and £0·84 million in deposits.

It will thus appear that in a period of thirty-four years, or roughly in the lifetime of one generation, the deposits held by the three main classes of banks have risen from £8·25 millions to nearly £59 millions. No doubt a very considerable portion of this additional capital has been contributed by British, Continental, and American merchants in business in India, but I think it will be admitted by all that the amount of purely Indian deposits has increased beyond all previous expectations.

A similar striking tale is told by the statistics of the co-operative banks. The earliest regularly constituted societies for agriculturists were established towards the end of 1904, but it was only in 1912 that a legal status was bestowed on the central banks, which attract funds from the general public for distribution among registered societies. The aggregate of the paid-up share capital and deposits from individuals in these central co-operative institutions in June 1916 was £2·2 millions. This is an achievement that cannot be pronounced anything but satisfactory, especially if it is remembered that this amount has been contributed by persons who do not expect and are not entitled to any loans. So far as these institutions are concerned, the capital available in normal times in the majority of provinces is now much in excess of the actual requirements of the movement in its present stage. Co-operative credit, if it is to take permanent root in the country, must be guided along carefully-guarded lines of development, and those responsible for the movement have wisely decided to prevent an exuberant growth at the cost of strength. Consequently deposits offered to the central banks have frequently to be refused and often returned. It has been suggested that the popularity of this class of investment is due to an idea that the Government is responsible for the solvency of these banks, but, so far as my own experience goes, there is no such general impression among the classes which actually invest in these banks.

Personally, I attribute their success to the tapping of a comparatively new stratum of depositors through the instrumentality of directors and managers who command local influence and confidence.

It is naturally impossible for an outsider to form an accurate idea of the different classes of people who nowadays deposit money in the banks in India. I had special opportunities of gathering information with regard to co-operative banks in my own province, and official duty as Registrar of Joint-Stock Companies in the province between 1912 and 1916 obliged me to examine the books of some of the smaller joint-stock banks that came to grief during that troublous period. Most of the depositors in both these classes of banks were recruited from the urban middle or professional classes. Here and there one came across the name of a landed magnate, and there were a few genuine agriculturists; and this is only what was to be expected on *à priori* grounds. In the interior of the country the industrialists and the commercial classes can, as a rule, utilize all available capital in their own business, while the natural instinct of a landholder is to invest his savings in the acquisition of more land. I am firmly convinced that the saving and investing habit can be fostered and developed to an almost infinite extent among what I have described as the urban middle or professional classes, and also under certain conditions among the landed classes.

Besides the four types of banks I have already adverted to, there are the Government savings banks run by the Post Office. They were organized in the present form in 1882, and by 1914 the number of depositors was over a million and a half, and the sum at their credit approached 16 millions sterling. The credit of the Government among the masses of India no doubt accounts for this remarkable growth; it will admit of expansion with the adoption of more elastic methods than have hitherto recommended themselves to a department of State.

In addition to these recognized types of banks, we still have in the towns and villages the two classes of individual bankers or banking families—the Seths or the big men, and the smaller moneylenders. In Bengal and in Madras new types of small corporations have been developed, known as *nidhis* and loan companies, but,

so far as I am aware, their methods are similar to those of individual bankers. Within limits, both the bigger and the smaller money-lenders invite and receive deposits from persons reposing confidence in them. Of course no figures are available. As I have said before, internal commerce is to this day very largely financed by the Seths, and the landed aristocracy usually resort to them when in need of loans. The village money-lender is still the financier of agriculture, and, in spite of the obloquy that is usually heaped upon him, continues to perform an exceedingly useful and important function in the State. Much as I dislike some of his methods, I should be sorry to see him improved out of existence at once. Perhaps my experience of the difficulties in the realization, through the processes of our civil courts, of money owed by contumacious members of credit societies, has inspired me with some sympathy for the money-lender's point of view. Legislation has been mooted to check the malpractices of money-lenders, and I hope that the remedies adopted will not be too drastic, in which case they will either remain a dead letter or seriously dislocate the entire business of agriculture. There is some danger of confusing the position and functions of the rural money-lender of India with those of the class in this country which merely exploits the vice and extravagance of foolish and ignorant people. In my view, the existing evils of usury in India will disappear with the spread of primary education among the masses and with the expansion of the co-operative movement which I trust will absorb the money-lenders among its depositors. Meanwhile, legislation is required for the registration of money-lenders, compelling them at the same time to maintain correct accounts.

I have now briefly sketched the different types of banks and bankers in India with whom deposits may be made on terms more or less advantageous to the depositor. For a person not himself engaged in industry or commerce, other means are also available for the investment of savings. The first in importance is landed property. In India, as in all old countries, ownership of land carries with it an implication of social standing and prestige, while, owing to the still surviving traces of insecure times, land is also

considered the safest form of investment. I may be accused of holding rather heterodox views on the point, but I have long been of opinion that a comparatively light assessment of the land revenue, specially in provinces where tenant-right is not strong or secure, unduly aggravates this land fever to the detriment of other and more productive forms of investment. I have in recent years frequently seen landed property purchased on the apparent basis of an annual return of less than 3 per cent., and on closer inquiry have ascertained that it was hoped to raise the actual return to 6 per cent. or higher. This state of things will probably be modified as soon as the clamant needs of local development throughout India bring about an enhancement of local taxation.

In the large commercial centres and in some provinces like Bengal, Government and semi-Government loans and other gilt-edged securities are the most popular form of investment. In Upper India they have been in lesser vogue, perhaps because there is no stock exchange or share-broker outside the Presidency towns, and securities of this type can be sold or purchased only through a bank or through the Post Office. The same difficulty affects the popularity, in the interior of the country, of good industrial securities like jute or cotton mill debentures and railway shares. Latterly, several branch or light railways have obtained in India all the capital they needed, and extensive advertisement has familiarized country investors with this form of enterprise. It is to be hoped that within a reasonable period of time respectable share and stock brokers will establish themselves in the more important commercial centres in the interior of India, and thus help forward the national thrift movement.

So far, practically all the different types of well-managed banks in India have restricted themselves to the financing of trade and commerce, that is to say, to the forms of banking business recognized as orthodox by the distinctively English tradition. I believe that European industrialists in India borrow from the banks comparatively insignificant amounts for purely industrial ventures, following in this respect the traditions of British industry. They have the advantage, in centres like Calcutta, of the "agency firms." These

firms undertake the finance as well as the superior business management of industrial ventures, and to a certain extent perform the functions of finance corporations or industrial banks. The system is not entirely free from attendant evils, but a European *entrepreneur* in touch with the presidency towns has no serious difficulty in obtaining capital for a sound proposition. Facilities of this kind are not yet available in the interior of the country, though a promising beginning has recently been made at Gwalior under the auspices of a well-known London finance house. The regular banks, whether managed by Englishmen or by Indians, cannot, in view of the proportion of capital to deposits held by them, lend to industries with any degree of safety. But even in England there is now serious questioning as to the adequacy of banking facilities for purely industrial purposes. In indigenous India, where wealth and *entrepreneur* capacity do not always go together, it has been contended that a different system, more perhaps on the models of Russia and Japan, should be adopted, and an industrial bank or banks should be organized with State aid or guarantee. The subject is too complex to be dealt with in all its bearings in the course of this paper, but it is difficult to see how the industrial development of the country, which is now so earnestly sought after by the Government as well as by the people, can be furthered without some modification of the accepted financial functions of the State. The Government of India have displayed, in the manifold risks that they have undertaken during the war, several instances of the two supreme qualities of confidence and imagination. They will be called upon in the interests of the country and the Empire to use these faculties even more after the war.

Another type of banking institution urgently needed in India is that of land mortgage banks. A few of the joint-stock banks used to do some business in land mortgage, but the recent crises have made them more cautious. It is not possible for the co-operative movement, as at present organized, to undertake the financing of large landed estates. I do not wish it to be understood that I have any sympathy with the encouragement of the landed classes in careers of vice and extravagance, but there is ample

room for the investment of money in their estates for agricultura improvements which will yield an ample return, though only in the course of a long period of time. The obstacles in the way of land banks are not so formidable as in that of industrial banks. Long-term bonds on the security of the mortgaged estates will probably prove an attractive form of investment, provided that certain technical difficulties are removed by legislation, *e.g.*, the uncertainty that usually attaches to loan transactions undertaken on behalf of a Hindu joint family or a Mussulman shareholder. The impulse in this case, as in many other forms of beneficent activity in India, has to come from the State, and it is to be hoped that the Government of India, which is now fully alive to the importance of agricultural improvements, will adopt early measures in this direction.

For some time past the question of a Central State Bank for India has been in the air. The Royal Commission on Indian Finance and Currency, which was presided over by the present Secretary of State and submitted its report a few months before the war broke out, without committing itself to any decided views on the subject, commended it as one which deserved early and careful consideration at the hands of a small expert committee in India. It seems to me that events are shaping themselves in a way that will leave the Government of India little option in the matter. For a long time to come the Government will have to rely on India itself for any loans that they may wish to raise for productive or development purposes, and a State bank will perform this function with much greater success than is at present possible. The co-operative movement is developing fast, and, as was indicated in the report of the Maclagan Committee, will soon need an apex bank for the whole of India, which will run smoothly only as a department of a State bank. If the Government commit themselves to the development of the resources of the country through State-aided industrial banks, then again a central State bank will be needed.

Whether a State bank is established or not in the near future, legislation is urgently needed to safeguard the entire movement of banking and thrift in India from unnecessary and unwholesome set-backs like what took place in 1913. The events that happened

then were foreseen by all careful observers, and it is noteworthy that in the summer of 1913, just before the panic occurred, the Government adumbrated proposals for banking legislation, and invited the expression of public opinion. Reform moves slowly in India, and the pre-occupations of the war have led to a postponement of the measure. I venture to submit that it is unsafe to leave this matter as one of the numerous after-the-war problems. At the end of the war there may be a renewed impetus for speculative, ill-managed, or dishonest enterprise. It is essential at the present critical moment that national thrift and sound banking should be encouraged by every possible means, and one of the means is to exterminate all doubtful pretenders to the name and prestige of a bank.

SALE AND LOAN OF AGRICULTURAL IMPLEMENTS.*

BY

THE HON'BLE MR. H. R. C. HAILEY, C.I.E., I.C.S.,

Director of Agriculture and Land Records, United Provinces.

THIS is not the first time that papers have been read at meetings of the Co-operative Conference on the subject of the sale and loan of agricultural implements by co-operative societies, but the course of the last few years has brought into prominence the need for certain implements, and I think it worth while dwelling on the subject again. The last three seasons have been marked by abundant rainfall extending well into October. There has been ample moisture for sowing wheat ; prices have been exceptionally good and *bhusa* has been at record prices. It might naturally, therefore, be expected that the area would have been above normal. So far from this being the case, in 1915-16 the area was about three-fourths of a million acres below that of 1914-15 ; last year it was over half a million below that figure, and this year it seems probable that there will be no great improvement over last year's figures. The reason generally given for this falling off is the difficulty experienced by the cultivators in preparing a seed bed suitable for wheat—particularly on heavier soils and in low-lying lands. As they could not break up the clods and prepare a fine tilth, they preferred to sow some other crop such as barley, the area under which has risen, or a mixed crop. The heavier soils of these provinces have

* A paper read at the Ninth United Provinces Co-operative Conference, held at Lucknow on December 18 and 19, 1917.

a tendency to run together and consolidate as a result of continuous rain, and it is this feature which makes subsequent preparation difficult. But it can be overcome with the necessary implements, and these implements are not beyond the means of the better class of cultivators, nor do they require any specially strong cattle to work them.

The ordinary cultivator has two implements, his plough and beam (*patela*). (I omit Bundelkhund, where conditions are somewhat different and where intensive cultivation is not aimed at.) The style of plough in common use is defective in many respects, though on light soils it does its work fairly well. But to obtain the desired tilth a large number of ploughings must be given, and in recent years this has been impossible. The cultivators are now grasping the fact that much better results can be obtained with the small iron ploughs, recommended by the Department, which invert and not merely grub up the surface of the soil and thus open it and clean it more thoroughly. The past three years have demonstrated their value, and there is not only a keen demand for them and an impatience at the difficulty in obtaining them, but what is more noteworthy there is a considerable sale of spare parts, showing that those already sold are appreciated. But besides these ploughs another implement is required for keeping the soils open after preliminary ploughings and to prevent consolidation during the rains. The cultivator ordinarily attempts to perform this operation, which is one of cultivating, or harrowing, and not ploughing, by means of his plough—that is, he tries to perform with a single implement what in other countries is done with several specially adapted for particular purposes. As noted above, in very light soils this can be done, but in the heavier soils containing varying proportions of clay (*matyar*) it is only possible when the season has been unusually favourable—that is neither too dry nor too wet—and such seasons can rarely be looked for. Take the case of the past three seasons. In each year there was early rain which enabled the land destined for wheat to be ploughed up before the monsoon set in heavily. Bright intervals during the monsoon permitted further ploughings; the land broke up into heavy clods during the operation, but this did not so

much matter as they were reduced by the next rain which dissolved them and at the same time consolidated the ground. But it did matter very materially when the cultivator was able to get on the land again in the second week of October for the final preparation before sowing. The ground was then drying fast and hardening; the action of the country plough, which is not a cutting but a tearing action, was to turn up the harder soils and those on which less preparation had been impossible, in big clods; on such land the country plough neither inverts nor pulverizes the soil; it simply turns it in hard lumps. The cultivators' usual method of getting rid of these is to pass the beam over them; this, however, only pulverizes a portion of them, the largest are simply buried or dragged to the side of the field. Another ploughing at this stage with the country plough would merely have the effect of turning up again the buried clods. But with a spring-toothed harrow much of this trouble might have been avoided. In the first place, with this implement it is possible to get on the ground sooner, before it has hardened to the same extent, and, looking to the great rapidity with which the upper surface hardens, this is very important; in the second, the operation is much quicker and time is valuable; and, lastly, its action tends to break up the land—not merely tear it apart—and it is especially designed for this purpose. Further, with this implement it is possible to stir the ground more frequently during the rains; a moderate-sized field is quickly finished, whereas with a plough the operation takes some time. The ground can consequently be kept in better condition throughout the rains. The land at the Cawnpore farm is distinctly on the stiff side, yet working with this implement which ordinary oxen can draw, after ploughing with an iron plough, the land has been got ready for wheat. In some parts of the provinces a wooden roller (*lakkar*) is used to assist in getting a fine tilth, but this is not very efficient as a clod crusher, and, even when improved with blades for clod cutting, has not been found so satisfactory as the spring-toothed harrow. More commonly the cultivator is reduced to breaking up clods with a stick, and gangs of men may be seen at this work, which is a tedious and costly method. It is not therefore surprising that many cultivators preferred to put

down some inferior crop on their land, trusting to winter rains to break up the clods. Planted on imperfectly prepared land the crop is not likely to be very good, and this means that in years when we have been very much favoured in the rainfall a lot of land is under inferior crops and not yielding what it should owing to absence of proper implements for preparing it. The implement referred to, which has been found most suitable for working the soils of these provinces after a preliminary ploughing, *viz.*, a spring-toothed harrow, can ordinarily be purchased for Rs. 25 to Rs. 30, but the price has temporarily gone up considerably.

What would appear to be the best equipment for cultivating the soils of these provinces in different seasons is the small iron plough and five-tine spring-toothed harrow. Most satisfactory results have been obtained with this combination in what is a very common and profitable rotation in Oudh and the eastern districts, *viz.*, wheat after maize on *do-fasli* land. If the maize stalks are removed with the plough which cleans the land and ploughs more deeply than the country plough, and this is followed by a thoroughly good harrowing with a spring-toothed harrow, a surprisingly good tilth is obtained. It is just these parts of the provinces where there has been the biggest drop in the wheat area—the Fyzabad Division showing a drop of over a lakh of acres under wheat—and those who have seen the state of the maize land this year after it has been grubbed up—it can scarcely be termed ploughing—for a *rabi* crop, I think, would agree that the case has not been overstated. The patience and perseverance of the cultivators in trying to prepare this land are most praiseworthy, and gangs of men and women could have been seen during the past month breaking up the hard clods with sticks. But the area which can be covered in this way is comparatively small, and some of the land cannot be sown with wheat. I would recommend to owners of private farms that they try this equipment of implements themselves and then make arrangements for lending to cultivators to demonstrate their value.

Another implement the Department is trying to popularize for the western districts is the lever harrow, which is most useful in

breaking up the crust which forms on the surface after canal irrigation. This crust the better cultivators break open with their *khurpis*, but the majority, I am afraid, trust to giving another watering to break it up and provide the necessary air for the plant. The practice is not only bad agriculture but most wasteful of water, and when water in canals is scarce it means that a certain area does not get sufficient water for maturing the crop. Quite early in the eighties it was common to find attention drawn to the undesirable effects of canal irrigation on the system of cultivation, the excess of water used leading to the formation of a thick surface crust which no efforts were made to break open. Instead of attributing it to its right cause the cultivators complained of some injurious qualities of the water. A light harrow run over the soil breaks up the crust quickly and does not harm the plants. One of these harrows will suffice for a number of cultivators.

To bring these implements to the notice of the cultivators and popularize their use is primarily the work of the Agricultural Department. This we are doing by lending them to enterprising men, though at present, as I have already explained, it is difficult to procure them in large enough numbers as the price is high. Wherever the spring-toothed harrow has been lent or bought, its value is highly appreciated, and when these implements can be purchased more cheaply their use is likely to spread. But the ordinary cultivator, even if he sees these harrows at work, does not know where to procure them from and often cannot pay the whole price outright. This is where the co-operative societies can come in. The sale of implements by co-operative societies has now perforce greatly declined, but I hope that after the war it will be revived and will be carried on more systematically. Cultivators are beginning to understand that not only is their equipment of implements in many points defective, but also that with better kinds they can get the work done more cheaply and thoroughly. Heavy implements which require stronger cattle or put too much strain on the cattle in use are not likely to be widely employed ; but these two harrows in the form recommended by the Department can be drawn by the cultivators' oxen. Their value, especially that of the spring-toothed harrow,

is beyond question, and if the co-operative societies arrange not only to stock them in depôts within easy reach of their members, but also sell them on the instalment system, they will be performing most valuable work for the agriculture of the provinces.

INDIA'S GREATEST INDUSTRY: SCOPE FOR AGRICULTURAL MACHINERY.*

BY

D. CLOUSTON, M.A., B.Sc.,

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THE development of labour-saving agricultural machinery is receiving much attention in England at the present time owing to the shortage of man-power due to the demands of our fighting forces. Necessity, it has been well said, is the mother of invention. English farmers conservative by nature have risen to the occasion, and thousands of self-binders, motor and steam ploughs, potato diggers, oil and steam engines for driving threshers, and other machines required for a well-equipped farm have, within the last $2\frac{1}{2}$ years, been introduced in rural districts where their utility had previously been but little understood. The impetus given by war to the introduction of these new agricultural appliances is likely to become a factor of first class importance in the rural economy of Great Britain, in so far as their adoption is enabling the farmer to reduce his labour bill, to increase both his acreage out-turn and profit, and to provide more food for the nation in arms.

The encouragement now being given to the invention and manufacture of new types of agricultural machinery in the West is likely to have a very wholesome effect on the development of agriculture generally in India. For as one of our most eminent expert agriculturists has said:—"Implements for tillage are of first class importance, and this is more especially the case in India where experiments conducted by the Agricultural Department have

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shown the great possibilities of increasing the yield of crops by improved methods. It is almost certain, however, that this will only be brought about by improved implements as the ryot has probably reached his limits with his present stock-in-trade."

A Tenfold Increase.

The demand in India for improved implements has arisen within the last decade or so ; it is increasing every year, as may be gathered from the annual reports published by Government. It can safely be said that the number of such implements now sold is ten times as great as it was ten years ago, and that the rate of increase henceforth is likely to be progressive. This is largely due to two main causes : (1) To the new spirit abroad consequent on the active measures taken by Government to develop the agricultural resources of India ; and (2) to the growing shortage and increased cost of manual labour.

The different Provincial Departments of Agriculture have not only created this demand for improved implements by practical demonstration, but have also established depôts at which both implements and spare parts are stocked for sale. In some provinces this pioneer work has also been taken up by co-operative societies. Despite the fact that most gratifying progress has been made on these lines within the last decade, Government has as yet, however, but touched the fringe of this great agricultural problem of providing the cultivator with more efficient implements. But it has at least prepared the way for much more rapid progress, and it is hoped that, after the war, enterprising English firms will not lose the golden opportunity of establishing business connections in our Great Eastern Empire, and of thereby helping in the development of its greatest industry—agriculture.

Study Local Conditions.

To solve the problem successfully it will be necessary to study local conditions and wants of the people. The local conditions vary from province to province and even from district to district in the same province. The Gangetic alluvium of the north of India

is quite unlike the stiff clayey loam of the Deccan commonly known as black cotton soil ; and a plough suited for the latter could prove too heavy for the former. There is great variety, too, in the crops to be dealt with and in the size and strength of the bullocks and buffalos which are the animals used for draught purposes. There are in parts of India good cattle the draught power of which is at least one-half that of a good Shire or Clydesdale horse at home : in other tracts where cattle are poor and neglected the average strength is very much less than that. The adoption of implements suited to the strength of various types of cattle is therefore important. In some tracts again many enterprising landowners are to be found who readily pay big prices for improved implements suited to their needs : in more backward tracts, on the other hand, the demand is for cheaper types only. But in designing agricultural implements suitable for India it should never be forgotten that both cheapness and simplicity of structure are of great importance.

The Iron Plough.

Of all the implements in common use in India perhaps none is more inefficient than the country *nagar* (plough). It may be briefly described as a piece of wood shod with an iron point which constitutes the share. It is fitted with a wooden pole and is drawn by from one to three pairs of bullocks. Having no mould board it stirs the soil without inverting it ; and having no cutting parts it does not eradicate weeds. Large areas have in consequence been overrun with weeds and gone entirely out of cultivation. All the improved ploughs which have been found suitable are types designed by enterprising firms after studying local conditions. One enterprising English firm at least has, after studying the requirements of the people on the spot, turned out ploughs of types which are being sold in thousands every year. These new designs are now well known all over India. The chief advantages claimed for them are that the parts are few, simple, easily adjusted and replaced. This is important in Indian villages where expert smiths are very rarely found. In one of the best known designs, namely, the "Turnwrest" plough, the share is provided with a cutting breast

made of self-sharpening chilled material which takes the place of a coulter. This plough has proved to be admirably suited for the cultivation of black cotton soil. The salient features of this soil are that it cracks freely during the hot weather to the depth of several feet, while the thin surface soil crumbles away and forms fine powdery loose earth. Below this thin layer, the soil, containing as it does a high percentage of clay, becomes very hard and compact in the dry weather which extends from October till June, during which time the cultivation of the land has to be carried out. To plough the dry hardbaked soil with country *nagar* is a difficult task which is as a rule resorted to after a long period of years. In the intervening years the cultivator uses only his *bakhar* or blade harrow which by repeated working pares off layer after layer of soil until he gets a tilth of about four inches.

Successful Examples.

The heaviest type of Turnwrest, or Ransome's Turnwrest as it is generally called, weighs 150 lb. Its pre-war price was about Rs. 45. It can be worked by one pair of good bullocks when the soil is moist, and by two pairs when dry. There is scope for the use of even heavier ploughs than this in India ; but it must be remembered that the average holding is small, and that heavier ploughs requiring more draught would be purchased by a relatively small number of cultivators. The makers claim that the " Turnwrest " or " One Way " plough, having as it has a reversible mould board, is specially suitable for ploughing lands under irrigation, as it lays all the furrows one way and leaves the land perfectly level. Now, as a matter of fact, this particular plough has found favour only in the cotton belt where the area irrigated is quite insignificant ; so we may take it that its success is not due to the mould board being reversible. Another very serviceable plough of medium weight designed by the same firm is the " Sabul " plough, the chief characteristic of which is that the share is provided with an adjustable bar point of high grade steel. The bar is held in position by a steel wedge knocked in from the front, so that the end pressure on the bar, when the plough is at work, tends to tighten the wedge.

By loosening the wedge the bar can be moved in or out as required. The bar point is sharpened at both ends and can be reversed.

There are several excellent light ploughs made by the same firm in use in tracts where the cultivation is done during breaks in or just after the rains. These light ploughs have long poles which are fixed direct to the yoke : they are guided by a single handle or stilt after the manner of the country plough. The main frame and slade are made in one casting. The breast is of hardened steel : the share is of self-sharpening chilled material and is usually fitted with a renewable point. For medium and light ploughs one pair of bullocks only is required. It is interesting to note here that the designs of this one enterprising firm have been copied by Indian firms who are turning out roughly made, but comparatively cheap, imitations of the English-made article, without let or hindrance. The main defect in these imitations is that the share is brittle and breaks readily.

Harrows.

The use of improved ploughs must precede the use of harrows and cultivators in Indian agriculture. The soil stirred by the country plough or pared by the blade harrow (*bakhar*) to a depth of only 3 or 4 inches is not benefited to any great extent by the use of such implements as the English harrow or cultivator the main use of which is to break surface clods. Worked immediately after an English plough on the other hand, which goes to a much greater depth thereby turning up large but moist clods, the disc harrow has been found to do such good work that there is reason to believe that a demand for it is likely to arise in the near future.

Cutters and Reapers.

A fodder-cutter suited for cutting the stalks of *jowar* (*Sorghum vulgare*), of which there are many million acres grown in India, would find a ready sale. English-made fodder-cutters, designed for cutting hay and straw, are not quite strong enough to cut *jowar*, a stalk of which is ordinarily as thick as man's thumb. An American machine known as the Harder fodder-cutter has found favour in

some parts of India, but the price is much too high being about Rs. 140. An imitation of a small American hand-chopper is now made and sold in considerable numbers in the Deccan, but the amount of work done by it per day is small. In the Central Provinces several Harder fodder-cutters driven by a Hunt's small spur-wheeled bullock-gear are in use and are working well.

A reaping machine suited for cutting *jowar* would be a boon in this part of the world where the crop is at present cut down, stalk by stalk, with a small sickle. A reaper to be suited would have to be high-geared and to have a short cut of from three to four feet. The fingers of the knife bar should be strong and further apart than in a wheat reaper, and the board and prongs of the "divider" should be long so as to support the stalks which are six feet or more in length. The pole should be so adjusted that the inner of the two bullocks will not trample down the standing crop. A reaper specially designed for *jowar* is now under trial in the Central Provinces and has given satisfaction. The scarcity of harvest labour in the Punjab and comparatively large acreage yields obtained have made reapers a profitable investment on wheat lands where they can be used; but their extended use in most parts of the wheat tracts of India is under present conditions out of the question, for the reason that labour is cheap and the acreage yield so very small that the crop can be cut much more economically by hand.

Threshing Machinery.

The need of improved threshing machinery for wheat is becoming more evident every year. Wheat-threshers are under trial at present and are giving promise of success. A bullock-power thresher of a suitable type should command a ready market. It is doubtful whether there is any opening for a hand-power thresher, the work of driving it being too hard for the ordinary easy-going Indian cultivator. To make the straw more edible a suitable thresher should have an attachment for chopping and bruising it, so as to break it up into short pieces as is done under the feet of the bullocks.

The primitive method in vogue in India, of treading out the corn with the muzzled ox, leaves the broken straw wheat and chaff mixed together. To separate the component parts a stronger draught is required than is usually provided by the ordinary type of grain-dresser in use in England. There are several good winnowers already on the market; many of these are Indian-made imitations of American and English winnowers which have been slightly modified to suit local conditions.

Miscellaneous Demands.

Some of the best cotton-growers in India still hand-gin their cotton (*kapas*) on a small wooden country mill. Worked by one person, the average quantity of *kapas* dealt with per day does not exceed 25 lb. A hand-gin capable of dealing with not less than 100 lb. of *kapas* a day would find a ready sale. In the absence of such a machine there has been a demand in the cotton tract of the Central Provinces for small ginning plants, each consisting of from two to four gins driven by an oil-engine.

In cane-growing tracts good bullock-driven cane mills find a ready sale. Light three-roller mills that can be worked by one pair of bullocks are most in favour. A certain number of small power cane-crushing mills has been set up in Bombay and Southern India, which are said to be giving great satisfaction. The small amount of work done by the bullock-driven mills in use at present is undoubtedly one of the greatest difficulties in the way of extending the area under this crop. The introduction of a small and efficient power plant, capable of crushing about 10 tons of cane per day, would be an enormous boon in cane tracts.

There is already a considerable demand for water-lifts, dairy appliances, and fencing material: there would be a demand, too, for a good retting machine suitable for retting the common fibre crops grown, but such a machine has yet to be designed.

How to Proceed.

To get into touch with the Indian market a British firm intending to do business in India should get the assistance of the

Agricultural Adviser to the Government of India and of the Directors of the Provincial Departments of Agriculture. The Director of a province, with his staff of agricultural experts and agricultural engineer, is in a very good position to say what the requirements of the cultivators are. He is always able and willing, too, to encourage the introduction of approved agricultural implements and machinery through official agencies. To start a successful business capable of great expansion it would be advisable for the firm to manufacture the bulk of its implements in India under the supervision of its own engineer whose duty it would be to design types to suit varying local conditions, in the light of knowledge gained on the spot and of the advice which would be willingly given by the Government.

Once established it would be necessary to advertise freely and to publish descriptive articles in the more widely read agricultural publications such as *The Agricultural Journal of India*. An article published in the April number of that *Journal* in 1913 (Vol. VIII, Part II) setting forth the merits of woven pigproof wire-fencing, but little known in India at that time, gave rise to quite a demand for that type of fence. I could quote many other instances to prove that in India there is a potential demand for improved agricultural appliances, but that judicious advertisement is necessary to bring their merits to the notice of the Indian landholders.

A FEW SIMPLE TESTS FOR USE OF DAIRY FARMERS, DAIRYMEN, AND STUDENTS.*

BY

R. OSBORNE, N. D. D. (I.)

In compiling this article the writer is not breaking new ground, as details of all the tests have already been published but are scattered through various works, and it is with the object of rendering them readily accessible that they are now being reproduced.

Some of the tests are very well known but are here mentioned in order to make the list as complete as possible.

Milk Testing.

The Gerber Test. This is a cheap and simple device for determining the percentage of fat in milk, cream, buttermilk, and separated milk, and will be described first.

The articles necessary are :—

(*a*) A centrifuge (known as Gerber's Butyrometer).

(*b*) Milk pipette holding 11 c.c. . .
(*c*) Acid „ „ 10 „ . .
(*d*) Alcohol „ „ 1 „ . .
(*e*) Special test bottles . .
(*f*) Stoppers for test bottles . .
(*g*) Stand for test bottles . .

} Supplied with machine.

(*h*) Sulphuric acid of a specific gravity of 1·825.

(*i*) Amylic alcohol „ „ „ „ 0·875.

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* Reprinted from the *Journal of Dairying and Dairy Farming in India*, vol. IV, part II.

Where again referred to in this article the whole of the above will be described as "Gerber's Test."

There are several special measures to facilitate and render safe the measuring of the acid and alcohol, but it is beyond the scope of the present article to describe them.

1. *To test fresh milk.*

Place the test bottles mouth uppermost in the stand.

Draw 10 c.c. of acid into the pipette which should be provided with a safety bulb to prevent the acid reaching the mouth, and place the forefinger over the end of the pipette (a plug of cotton-wool may be placed in the mouthpiece if desired for additional safety). Allow the acid to run into the test bottle, taking care that the neck of the bottle is kept dry.

It is unnecessary to blow the last drop out of a pipette.

Similarly measure 11 c.c. of milk and add to the test bottle. Great care must be taken to avoid violent contact between the acid and milk. It is best to allow the milk to run gently down the side of the bottle.

Now add 1 c.c. of amylic alcohol.

It is essential that all liquids should be carefully and accurately measured.

The neck of the bottle must be kept dry, or there is a risk of the rubber stopper flying out.

The test bottle should now be corked with the rubber stopper which should be well pushed home.

Invert and shake the bottle until all the casein has been dissolved by the action of the acid. The mixing of the milk and acid causes a rapid rise of temperature, and it is advisable to hold a bottle with a cloth while shaking.

The bottle should now be placed in the centrifuge with the stoppered end outwards, and revolved for three minutes.

On removing the bottle, the fat will be found collected in a clear column at the thinner end of the bottle.

The column of fat, if not already there, must be brought on to the graduated scale.

This may be done by either pushing in or slightly withdrawing the stopper. It may be pointed out, however, that it is far better to arrange the position of the stopper *before* the bottle is put into the centrifuge instead of after rotating.

Get the lower end of the column of fat level with one of the long graduations on the scale, and it is then a simple matter to read the result. Each long division of the scale is equal to 1 per cent. of fat in the sample, and each short line is equal to 0·1 per cent.

Greater accuracy is ensured if a pair of dividers is used for measuring the column of fat, to avoid having to raise or lower the column, as in the latter case a thin film of fat remains adhering to the glass and slight errors result.

It will be observed that the upper end of the column of fat has a curved surface called the "Meniscus." The reading should be taken to the bottom of the Meniscus.

Note. It is important that the sample of milk should be thoroughly mixed immediately before testing. This can be done by pouring from one vessel into another several times.

2. *Testing separated milk.*

The process of testing separated milk is the same as for whole milk, except that a special test bottle with a tapered scale known as the "Precision" test bottle is recommended as giving greater accuracy. It is also necessary to remove the bottles from centrifuge after rotating for three minutes and place them in a water bath at about 170°F., rotate for another three minutes, again place in the bath, and finally rotate for one minute.

This ensures the complete separation of the fat. Results should be read in this and all cases when the contents of the test bottles are at a temperature of not less than 140°F.

3. *Testing buttermilk.*

This is done in the same way as separated milk.

The chief difficulty is to obtain a correct sample. The amount of breaking water added to the churn should be noted.

The whole of the buttermilk should be drawn off and weighed, and a sample taken.

The quantity of breaking water should then be taken into consideration when reading the test, and the correct reading calculated.

4. *Testing partly churned milk.*

When milk has been partly churned, heat the sample in a hot water bath until the fat is melted, then thoroughly shake the sample until the whole is a perfect emulsion, and test immediately in the normal way.

5. *Testing frozen milk.*

When milk freezes the outer portion of the milk has a very low fat content, and the milk must be thoroughly thawed and well mixed before testing.

6. *Testing sour milk.*

When milk has curdled the curd may be broken up by the addition of ammonia. Take some ammonia and dilute it to the proportion of one part of ammonia to four parts of water. Add 5 c.c. of this to 100 c.c. of milk. Shake gently until all the casein is dissolved. Test this mixture in the ordinary way.

The fat reading must then be increased by $\frac{1}{20}$th to allow for the ammonia added, *i.e.*, if the fat reading is 6 per cent. the correct reading would be 6 plus $\frac{1}{20}$ of $6 = 6{\cdot}3$ per cent.

The Lactometer.

The lactometer is an instrument which registers the specific gravity of milk. It is often advertised as an instrument which will test milk. This is incorrect, but it is frequently desirable to know the specific gravity of a given sample of milk in order to calculate the total solids.

The lactometer requires very careful handling to ensure correct results.

It must be kept scrupulously clean, as a little dust is sufficient to impair its accuracy while if it is put away after use without careful washing the next reading is certain to be inaccurate.

The lower part of the lactometer is a weighted bulb, and the upper part a stem or rod with a scale marked thereon.

Lower the bulb slowly and carefully into the milk, which, as usual, must be well mixed previously. Care must be taken that no part of the instrument touches the vessel, and it is an advantage if the eye can be brought on a level with the surface of the milk to ensure correct reading.

If froth is present it must be removed. Observe the figure at the surface of the milk, and this will indicate the specific gravity of the sample.

For the sake of uniformity, the lactometer is made to register the specific gravity of milk at 60°F., as the density of liquid varies with the temperature.

This point is important, but often overlooked. It is best to have the milk as near 60°F. as possible, but variations from this temperature can be allowed for as follows :—

For every degree of temperature above 60°F. add 0·1 to lactometer reading, and for every degree below 60°F. deduct 0·1 from the lactometer reading.

This correction may also be rapidly made with the aid of a Richmond Scale, which will be described later.

The specific gravity of genuine milk varies with different samples, dependent upon breed of animals, period of lactation, individual characteristics, and many other factors.

It may be said to range between 1·028 and 1·034 at 60°F., but there are exceptions even to these wide variations.

Fats reduce the specific gravity, being lighter than water.

Other solids increase the specific gravity, as they are heavier than water.

It is evident, then, that the use of the lactometer is limited. It is only of practical use when combined with an apparatus for testing the amount of butter fat present.

Estimation of Total Solids.

To estimate the total solids in milk, it is necessary to know (1) the percentage of fat present, which can be ascertained by the

Gerber Tester ; and (2) the specific gravity at 60°F. as indicated by the lactometer.

With these data, the total solids can be calculated by the following formula :—

$$\left.\begin{matrix}\text{Total} \\ \text{solids}\end{matrix}\right\} = \frac{\text{Specific gravity}}{4} + \frac{(\text{Fats} \times 6)}{5} + 0{\cdot}14$$

This calculation is much simplified by the use of the " Richmond Milk Scale."

The scale is constructed with a twofold object. The necessary correction of the lactometer reading, when the temperature of the sample is not exactly 60°F., may be immediately ascertained, and the percentage of total solids rapidly calculated.

The scale is constructed with a sliding slip in the centre and is used as follows :—

Use of Richmond's Scale to obtain corrected specific gravity.

At the top of the scale to the left will be found a scale marked " Temperature."

On the top edge of the movable centre slip will be found a scale marked " Lactometer Readings," ranging from 22 to 37.

To obtain the corrected specific gravity, place the lactometer reading obtained opposite the line marked 60°F. on the temperature scale and the corrected specific gravity will be found opposite the temperature at which the lactometer reading was taken. For example, if the actual reading was 32 at 65°F. place 32 opposite 60°F., then in line with 65°F. will be found 32·65 which is the corrrected specific gravity.

To find total solids.

Now that the percentage of fat and the correct specific gravity are known, the total solids may be found as follows :—

On the right top side of the scale is a scale of fat percentages.

On the right top of the sliding centre piece will be found an arrow.

On the bottom edge of the sliding piece is a scale of specific gravities.

Along the bottom of the scale is a scale marked " Total Solids."

Place the arrow opposite the line showing the percentage of fat present in the sample.

Find the corrected specific gravity on the lower edge of sliding scale.

The line of the specific gravity will correspond with the total solids on bottom of scale.

For example, suppose a sample of milk has a fat percentage of 3·5, and a lactometer reading 32·65, then, by placing the arrow against 3·5 on the scale marked "Fats," it will be seen that the specific gravity 32·65 is in line with 12·55 on the total solid scale. Thus 12·55 per cent. represents the total solids in the sample.

It will be noticed that the scale will only calculate milk with fats less than 6 per cent.

Buffalo's milk is usually higher in fats than this, but the solids may be calculated by dilution of sample with an equal quantity of water, and then multiplying all results by 2.

Other Milk Tests.

Artificial colour in milk.

To test for artificial colouring matter in milk, which is sometimes added to give the milk a fictitious appearance of richness, take 10 c.c. of milk and add an equal quantity of ether. Shake well and then stand until ether rises to the surface.

If the milk is uncoloured the ether solution will be colourless; but if colouring matter is present the ether solution will be coloured.

The intensity of the colouring will give an idea of the amount of colour added.

Controls of milk known to be uncoloured should be prepared for comparison.

Detection of Preservatives.

The commonest preservatives used in milk and milk products in India are boric acid and other boron compounds, and formalin or formaldehyde. These are active poisons, and their use even in very minute quantities should be discouraged, and it is considered that their presence should always be declared. When it is

remembered that large quantities of milk are consumed by infants the importance of the subject can be realized.

Boric Acid or Borax.

To detect the presence of these preservatives proceed as follows :—

"Take a small quantity of the suspected milk (15 c.c. is a handy quantity). Add a few drops of phenol-phthalein, and then allow diluted caustic soda to drop in until the milk acquires a delicate pink tinge.

"Now add an equal quantity of a mixture made up of equal parts of glycerine and water.

"If borax or boric acid is present the pink colour disappears, but if no preservative is present no change occurs."

Formalin or Formaldehyde.

To detect the presence of this preservative pour some strong sulphuric acid into an ordinary test tube. Dilute a small quantity of milk with an equal volume of water, and run the mixture into the test tube, allowing it to run down the side.

Watch the line of junction between the two liquids. If formalin is present a violet ring is formed. If no formalin is present a greenish colour appears which quickly changes to brown.

The colour is more pronounced if a few drops of ferric chloride are added before the acid.

A Rapid Test for Acidity of Milk.

In creameries, where milk is pasteurized before separation, it is often desirable to know whether milk will stand the pasteurizing temperature without curdling. It has been found that milk with an acidity of more than 0·2 per cent. cannot be satisfactorily pasteurized.

Take 10 c.c. of the doubtful milk, add three or four drops of phenol-phthalein, and then add 2 c.c. of caustic soda solution.

(The preparation of this solution is described under the head of "Test for Acidity of Cream.")

If the milk remains white it is unsafe to attempt to pasteurize, and it should be separated unheated.

If the sample turns pink it contains less than 0·2 per cent. of acid and will stand the pasteurizing heat.

* * * * * * * * * *

It is desirable now to refer briefly to the advantages which accrue to dairy farmers and others through being able to carry out simple and inexpensive tests of dairy produce.

That advantages exist none will dispute, but it is intended to indicate some of the more important ways in which testing may be put to good account :—

1. Milk testing enables a farmer to detect unprofitable animals, more particularly when it is his aim to produce butter-fat.
2. It has made possible the purchase of milk according to quality. This has made the modern creamery practicable.
3. Adulteration may be detected and checked.

The only class of person to whom this is not an unmixed blessing is the dishonest milk vendor.

In this connection it may be pointed out how different classes of adulteration will be indicated. It is unfortunately far more difficult to detect and check adulteration in India than it is in countries where dairying is in a more up-to-date condition.

The principal causes of this are :—

(*a*) There are no universal regulations in India controlling the sale of milk, and in consequence adulteration is very widespread.

(*b*) The milk of cows and buffalos is sold either separately or mixed, and the composition of milk is very variable even when genuine.

(*c*) There is very little information available as to the average composition of genuine milk in India, which is however far richer than in Europe and America.

(*d*) The production of milk is generally in the hands of illiterate and dishonest dealers.

As before mentioned, the existing information relating to the composition of Indian milk is meagre, but the following are figures obtained by investigators at Poona when testing a fairly large herd and may be accepted as reliable. The testing was carried out by means of the Gerber Tester, the Lactometer, and Richmond's Formula:—

	Water	Fats	Proteids	Sugar	Ash
Buffalo's milk	81·1 to 82·2	7·6 to 8·7	4·2 to 4·3	4·7 to 5·2	0·8
	Solids not fat ...		9·9 to 10·4		
	Total solids ...		17·7 to 18·8		
Specific Gravity at 60°F. 1·031 to 1·0315.					
Cow's milk	84·9 to 85·8	5·3 to 5·8	3·5 to 3·8	4·4 to 4·9	0·7
	Solids not fat ...		8 8 to 9·3		
	Total solids ...		14·2 to 15·1		
Specific Gravity at 60°F. 1·029 to 1·030.					

It must be borne in mind that the above figures make no pretence at showing extremes in exceptional animals, but are intended to show the class of milk an average herd should produce.

When the quality of a sample of milk is suspected, first determine the percentage of fat, then find its specific gravity, and calculate solids not fat and total solids.

In drawing conclusions relating to suspected adulteration remember that—

(*a*) fat is lighter than water,
(*b*) milk is heavier than water,
(*c*) skimming increases the lactometer reading,
(*d*) skimming decreases fats and total solids, but does not materially alter the solids not fat,
(*e*) watering decreases fats and total solids,
(*f*) skimming and watering may give a normal lactometer reading.

The following table of examples is appended to show the conclusions which may be arrived at in dealing with suspected milk from a herd of cows :—

	A	B	C	D
Fats	5·5	3·9	4·2	4·0
Solids not fat	9·0	8·8	9·0	8·0
Total solids ...	14·5	12·7	13·2	12·0
Lactometer reading ...	1·030	1·030	1·032	1·027

A is considered to be a genuine sample ; B is probably watered and skimmed because fats are low, lactometer reading is normal, and total solids low ; C is probably skimmed because lactometer reading is high and fat is low, solids not fat being normal ; D is probably watered because everything is below normal.

Cream Testing.

There are two tests of cream which are of importance to the butter maker.

The first is to test the cream for butter fat and the second for acidity.

The butter fat test assists the butter maker to accurately calculate the overrun and thus eliminate losses.

The acidity helps to ensure a uniform quality and flavour of butter and also promotes exhaustive and complete churning. In both these objects the butter maker is also assisted by the tests for fat in butter milk and water in butter, both of which are mentioned elsewhere in this article.

Testing for Fat in Cream.

Measure 11 c.c. of cream with a milk pipette and pour into a small vessel. Then take 6 or 7 pipettes of water, and thoroughly mix with the cream, making sure that all the cream is washed out of the pipette. Test this mixture by the Gerber method in the same way as milk. Multiply the result by the total number of pipettes used, that is, if 6 pipettes of water were added, multiply by 7. The object of the dilution is to bring the reading within the scope of the ordinary test bottle.

Many writers advocate the weighment of cream instead of measurement, as ensuring great accuracy, and it is an undoubted

fact that the specific gravity of cream decreases as the percentage of fat increases : so a distinct possibility of error is introduced by the measurement instead of weighment.

When the pipette system of dilution is carried out a small correction is necessary.

This correction is shown in the following table :—

Per cent. fat found	Correction to be added	Per cent. fat found	Correction to be added
20	0·12	.....	.....
21	0·16	36	0·83
22	0·19	37	0·90
23	0·23	38	0·96
24	0·26	39	1·03
25	0·30	40	1·09
26	0·34	41	1·17
27	0·38	42	1·24
28	0·42	43	1·32
29	0·45	44	1·40
30	0·48	45	1·48
31	0·54	46	1·56
32	0·60	47	1·64
33	0·66	48	1·72
34	0·72	49	1·80
35	0·77	50	1·89

If the dilution method by weighment is desired, carefully weigh 10 grammes of cream.

Then measure 60 or 70 cubic centimetres of water and proceed as above described.

This method greatly reduces the margin of error as the water can be measured in bulk in a burette instead of with a pipette, while the weighment of cream eliminates the error due to varying specific gravities.

In carrying out this test the following sources of error should be avoided :—(1) Sour cream ; (2) use of wet pipettes or flasks when first measuring out the cream ; (3) careless mixing, whereby air bubbles are drawn into the pipette along with the cream ; (4) drawing the cream too far above the mark in the pipette ; (5) loss of fat when adding water for dilution ; (6) imperfect mixing of the diluted cream ; (7) fine particles of fat left on the pipette when the diluted cream is run into the test bottle ; (8) reading the results at too low or too high a temperature.

Test for Acidity in Cream.

The principle of this test is as follows :—

A few drops of phenol-phthalein are added to the cream to be tested.

This substance is colourless in the presence of an acid, but turns pink in the presence of an alkali. The change of colour indicates the point when all the acid has been neutralized and the liquid becomes alkaline. The degree of acidity is found by using an alkali of known strength and noting how much alkali is necessary to neutralize the acid in the sample. Caustic soda is the most common alkali used.

Apparatus required. (*a*) A burette for measuring the caustic soda solution graduated in cubic centimetres and tenths of cubic centimetre. (*b*) Caustic soda solution (prepared by dissolving 4·5 grammes of 98 per cent. pure caustic soda with one litre of distilled water). (*c*) Phenol-phthalein. (*d*) Pipette holding 10 cubic centimetres. (*e*) Small porcelain dish. (*f*) Glass rod for stirring.

Method. Accurately measure 10 c.c. of cream, add three or four drops of phenol-phthalein. Note quantity of caustic soda solution in the burette.

Allow the caustic soda solution to fall from the burette drop by drop into the sample. Close watch must be kept and the sample stirred. When a permanent pink tinge is apparent, the addition of the soda solution must at once stop.

Read from the burette the number of c.c. of soda solution used.

In this method 1 c.c. of caustic soda solution used indicates that 0·1 per cent. of acid has been neutralized, and the calculation of the result is therefore simplicity itself.

For example, if 4 c.c. of solution are used, it indicates that 0·4 per cent. of acid was present in the original sample, or if 5·5 c.c. are used the acidity of the sample was 0·55 per cent.

To Ascertain Percentage of Water in Butter.

For this purpose a special apparatus known as the Sorensen's Tester is recommended.

The maker's instructions for the use of the apparatus are as follows :—

A small portion, weighing not less than 10 grammes of the butter to be tested, should be placed in one of the empty bottles provided with the apparatus and the stopper put on. Melt the butter by standing the bottle in hot water, about 140°F.

Place the metal dish with the glass stirrer in it upon the balance ; adjust the screw at the end of the arm at the balance, so that the weight of the dish and the glass rod is exactly balanced.

Remove the dish from the balance and pour into it about 9 to 10 grammes of melted butter ; shake the bottle immediately before pouring out the butter to ensure obtaining a uniform sample.

Replace the dish with the stirrer and the butter in it upon the balance and weigh it by means of the movable weights placed upon the lever. These weights are of three sizes, the largest represents 1 gramme, the next size 0·1 gramme, and the smallest 0·01 gramme. For example : If the largest be in the notch marked 8, the second size in the notch marked 6, and the smallest in the notch marked 4, the weight of the butter will be 8·64 grammes.

Remove the dish with the butter and the glass rod on to the tripod and heat it by means of the spirit lamp stirring it in the meanwhile until all the water has evaporated. When the butter has ceased to foam the dish is removed and set aside to cool.

After cooling, weigh it again, including the glass rod, and deduct the second weight from the first, which will give you the amount of water which was contained in the sample and from which you may easily calculate, according to the following form, the percentage of water which it contains.

For example :—

Original weight of butter	9·60	grammes.
Weight of butter after heating	8·50	,,
Weight of moisture	1·10	grammes.

$1{\cdot}10 \times 100 \div 9{\cdot}60 = 11{\cdot}46.$

The butter contain ed 11·46 per cent. of moisture.

An ordinary chemical balance may be used for this purpose with similar dishes and rods, but the process is more lengthy and troublesome.

Notes.

ACACIA MODESTA, A HEDGE PLANT.

The photographs reproduced (Plate XX) may be of interest to those who are trying to grow hedges or testing plants with that object in India. The plant is *Acacia modesta*, not indigenous to Burma, but, I think, to the greater part of North-Western India. It produces a very thick, impenetrable hedge in a short time and is here (Mandalay) far superior to any of the other plants, *e.g.*, *Inga dulcis*, *Acacia arabica*, *Duranta*, etc., that have been tried.

Acacia modesta if properly treated does not, like *Inga dulcis* and some other plants, grow tall and form a top without any thickness below. It is impenetrable to the ground and at two years old the hedge shown in the photographs was quite impassable even for a hare. Moreover, this plant does not require so much cutting as some others, like *Acacia arabica*, which send out strong shoots so freely that it is difficult to keep them within bounds without continual clipping. Two (or at most three) clippings are given annually to the hedge shown. The spines of *A. modesta* are plentiful but not so long as those of *Acacia arabica*.

This hedge is growing on a stiff, impervious clay where trees and few plants can be grown without the greatest difficulty, yet at two and a half years old it was about 4 feet high, the desired height, and so thick that no stock, not even a buffalo, would try to pass through it. It has since gradually thickened and at seven years old is still thriving, and to all appearances will continue for several years more before it needs cutting down. It withstands the extreme dry weather, except when very young (the first year) without water though it loses some of its leaves at that time if not watered. Even then owing to the free branching it is not possible to see through the hedge.

We have so far been able to grow it from seed only—cuttings do not "take." The seed should be sown as soon after it is ripe as possible, *i.e.*, about September-October.

On this waterlogged soil we sow on a slight ridge in a single line about one seed to the inch and cover with ½ to 1 inch of soil. On more genial soil less trouble should be required. If rains are unfavourable watering is necessary till the following monsoon. Judicious clipping when the plants are young will induce free branching and easily give density below. The hedge should of course be allowed to attain the required height and thickness by slow degrees—each clipping permitting it to grow a little larger. If this is not carefully attended to density is lost. If cut down almost to the ground *Acacia modesta* will shoot again freely, so that it should not be difficult to renovate an old hedge.

When clipped into the form of a hedge the plant seldom produces any seed and the supply of this for further sowing is a great difficulty here, for there is a lively demand which we are entirely unable to meet. Seed obtained from the Punjab did not germinate—partly because it was badly damaged by larvæ of some insect, but largely, we believe, because it was old and had lost its vitality. We shall therefore be greatly obliged if any reader of these lines in India can help us in obtaining fresh seed.

This plant, the merits of which were discovered by accident, is strongly commended to the notice of those who wish to grow useful and at the same time ornamental hedges.—[E. THOMPSTONE.]

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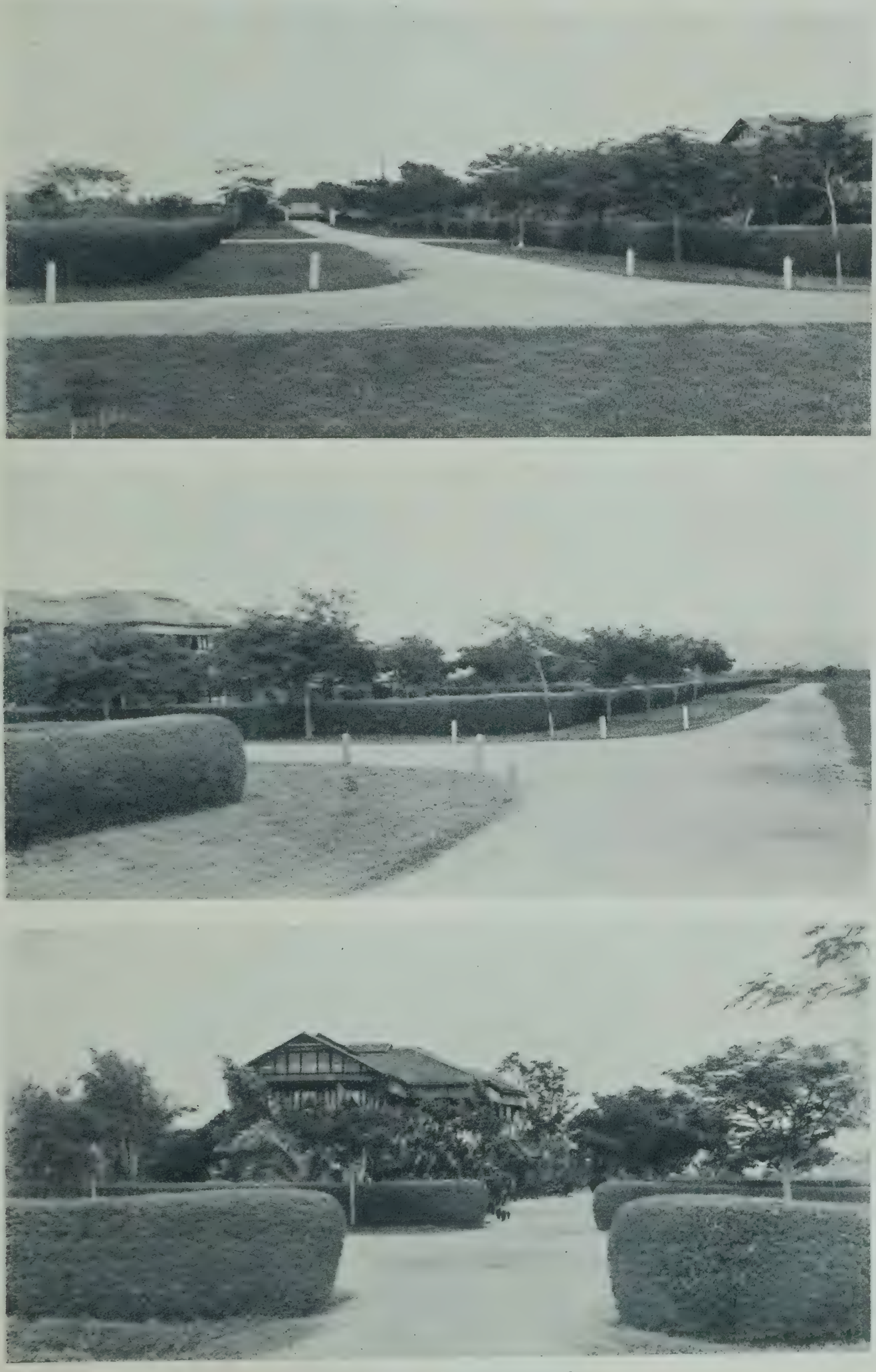
WITH regard to **bee-keeping,** the following note by Mr. W. P. Thompson, Executive Engineer, Public Works Department, Irrigation Branch, Hafizabad Division, Lyallpur, will be read with interest :—

I had often read with interest of bee-keeping as a cottage industry when a coincidence made me a bee-keeper's neighbour for a period of four weeks during leave taken in the summer of 1915.

Bad fortune took me to the Seychelles and good fortune made the bee-keeper my neighbour. This enterprising man had imported



Typical Hedges of *Acacia modesta*.

fertile Italian queen bees from Italy by post and had succeeded, when I met him, in establishing an apiary of some twenty colonies, and much honey did we consume during these weeks. It was purchased at the interesting price of four annas for a frame containing a pound and a half of honey.

On my departure from the Seychelles I purchased two queens at Rs. 3 each, but, owing to my ignorance of the habits of my royal captives, they perished from cold before I reached my destination, and my effort at introducing these active workers into another corner of the Empire failed entirely.

On my return from leave a notice in the *Pioneer* brought to my knowledge the existence of the Simla Bee-keepers' Association, and the publication on bee-keeping by the Pusa Institute.

I had a hive made and even captured several swarms of *Apis florea* which, however, are not domestic and would not accept the hospitality of my hive in spite of proffered syrup.

A fortunate coincidence in the summer of 1917 made me the neighbour of Mr. Cousins at Kasauli, and with his courteous assistance I have been able to start experimentally with bee-keeping at Lyallpur, and the inauguration of this colony in its new surroundings I proceed to tell about.

During the winter months of 1915 and 1916 I had noticed in my compound and neighbouring ones several colonies of *Apis florea*, and this was certainly an indication that congenial pasturage was available. Having secured the necessary implements I brought down a swarm of *Apis indica* from Kasauli, starting on the 7th of October and having them at Lyallpur on the 10th.

The weather was propitious and the bees accepted their new surroundings and brought in from the *kikar* (*Acacia arabica*) trees and the *toria* (*Brassica Napus*) crop, then in bloom, all that they required.

By the 3rd of December they had got on so well that they swarmed. This swarm was captured on the 4th and hived. Successive swarms issued on the 11th and 12th.

The third swarm, which I was able to capture on the day of issue, I united with the first swarm.

The fortunes of the second swarm are worth relating.

I captured them on the evening of the 13th and hived them.

I allowed them to fly on the 14th, but at 3 o'clock in the afternoon, they left the hive, and after settling first on one tree, then on another, finally settled on hive No. 1 (the original hive) and filed into the hive every one of them.

So I have now two colonies of fair strength which, to all appearances, are comfortably settled, and I have hopes of seeing a good honey flow in January, February, and March when there is a profusion of flowers in Lyallpur.

The swarming in December is attributed by Mr. Cousins to the heat inside the hive, and I think he is right as I was inclined to make them over-comfortable on account of the cold nights prevailing at the time.

I consider that the swarming was a good thing for me as I have now two hives and have moreover learnt quite a lot about my charges during this interesting period.

It also shows that one can increase the numbers of colonies in an apiary at a faster rate in the Plains than in the Hills, and this fact should be encouraging to would-be bee-keepers.

The issuing swarms, especially the first and second, were very numerous, and the original colonies did not look depleted after the swarming ; so far, therefore, everything has been propitious.

Since I started my first hive I have increased the number of frames in it from six to nine.

After the issue of the third swarm from my first hive I examined all the frames and cut out as many queen cells as I could find. They seemed to be all old ones, but I propose to keep on removing all embryo queen cells till February as it would certainly be inadvisable to have further swarming till then.

I think it is advisable to place on record an observation made this year with regard to *Apis florea.*

As I mentioned above, in the years 1915 and 1916 I noticed in the winter many colonies settled on the trees in and around my compound.

This year I have so far only noticed one and I fear the late rains are the cause of this reduction in their numbers.

The hive used by me is a Cowan-Cousins hive which has been evolved as the result of much experimenting and is the hive *par excellence* for *Apis indica* either in the Hills or the Plains.

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THE FOOD-VALUE OF THE GROUNDNUT.

A Press Note, dated 6th November, 1917, issued by the Government of Bombay, says :—

The groundnut, pea-nut, earth-nut, or monkey-nut (*Arachis hypogœa*) is a leguminous creeping plant indigenous to India. Although the fruit resembles a nut in that it contains fat it is really a legume. After flowering, the stalk of the plant bends over and enters the soil, where the seeds grow and mature. These seeds are contained in paper-like pods or husks, and there are usually two, but in some varieties four seeds in each pod. For commercial use these nuts have to be decorticated, and the shell is usually broken by special machinery. The inner red skin covering the kernel is then removed as completely as possible by a blast of air. The separated and cleaned kernels are ground up and subjected to hydraulic pressure to obtain the oil. This oil, known as Arachis oil, or *Katchung oil* in India, is obtained either by two, or sometimes three expressions.

The first expression of oil takes place at the ordinary temperature, and yields a cold drawn oil, which is nearly colourless, has a pleasant taste and odour, and forms a most valuable substitute for olive oil. It keeps very well, but on exposure for some time it has a tendency to thicken, and only then does it turn rancid.

The second expression is carried out at a temperature of 30° to 32° C., and the resulting oil may be used for culinary purposes, for the manufacture of margarine, as a lubricant, and also for burning purposes.

The third expression requires a still higher temperature, *viz.*, 50° to 55° C., and this represents a lower grade oil, which is suitable for soap-making.

After expressing all the oil the press-cake is usually sold as a cattle food and is much valued as such, since it contains the highest protein content of all known cakes, and further has the advantage of easy digestibility. It is the purpose of this article to demonstrate the value of this cake as a foodstuff, and also the lines along which this industry may be developed with success.

In India, more particularly in the Bombay and Madras Presidencies, this groundnut industry is a large one, and before the war the nuts were exported from India in very large quantities, chiefly to France. Here the oil was expressed (of which from 45—50 per cent. is present in the Indian samples) and used for soap-making, and the result of this was that groundnut oil, or Arachis oil as it is commonly called, was cheaper in France than in India. The true kernel of the Indian groundnut has the following composition :—

	Grammes per cent.
Water	7·5
Protein	27·5
Fat (Arachis Oil)	44·5
Carbohydrates	15·7
Fibre	2·2
Ash	2·5

After the Arachis oil has been removed, and the resulting cake allowed to dry in the sun and finally reduced to a fine powder, this powder has the following composition :—

	Grammes per cent.
Water	9·8
Protein	44·5
Carbohydrates	23·8
Fat	9·2
Fibre	5·2
Ash	7·5

It is evident from the analysis that this groundnut meal represents a highly nutritious food, not only for cattle, but for human beings. At present this press-cake is either used as cattle food or as a manure. Now this flour is not only rich in proteins which are essential constituents of all foods, but these same proteins have a peculiar composition, which make them particularly effective in supplementing food products of cereals whose proteins lack these special constituents. The proteins in our ordinary food are built

up of certain amino-acids which are linked together just like the building stones of a house. Now all proteins contain these amino-acids, or building stones, but some essential ones are missing from the proteins of certain foods, and others again are present in varying proportions. Thus it has been shown that neither animals nor men can maintain their body, weight and proper growth and nutriment when fed on maize, or certain legumes. Similarly the proteins in wheat and barley, whilst sufficient to maintain body nutriment, will not suffice to promote growth. The first two have been shown to be due to the absence of a certain building stone, an amino-acid known as tryptophane, and the second two proteins to an absence of another building stone known as lysine. In order therefore to maintain proper nourishment and growth, the proteins taken in with the food must contain these two amino-acids, *viz.*, tryptophane and lysine, and it is because meat proteins satisfy this condition that they form such a valuable food. Now it is well known that vegetable proteins will not replace animal proteins in a dietary, and hence a perfect food must be made up so that all these building stones are not only present, but also occur in suitable proportions.

Now, we find that groundnut cake, besides containing a high proportion of protein, contains certain amino-acids in quantity. These amino-acids belong to the same group as those found to be deficient in the proteins of wheat and barley, *viz.*, lysine. By mixing groundnut meal with wheat flour and other cereals we are able to add these missing building stones. Again the particular proteins in the groundnut meal are deficient in the amino-acid tryptophane, so in order to overcome this deficiency we add dried milk in certain proportions. The groundnut cake when mixed with dried milk therefore gives us a flour of very high protein content; these proteins contain, as far as we know, all the various building stones necessary for growth and maintenance of nutrition. We find, however, that these two constituents do not go into solution very readily, hence the flour is mixed with sodium carbonate or bicarbonate, in which the other two constituents are readily soluble. The new flour thus consists of groundnut cake, dried milk, and bicarbonate of soda. The bicarbonate of soda acts also as a

preservative, and assists in the process of baking. All these three constituents can be obtained in India in any quantity, and at a very cheap rate. The materials used may be prepared with the use of the existing mill machinery so that no additional outlay of capital is required.

Now, besides containing a large amount of protein, this new flour is rich in fat and mineral salts. Of the latter the most important feature is its richness in phosphates (phosphoric acid). In all foods mineral salts cannot be replaced by any of the other forms of nutritive material present, *e.g.*, proteins, fats, and carbohydrates. The carbohydrates and fats in the food supply the chief source of energy for the production of heat and work, and to a certain extent these may be interchanged, but neither of these nutritive constituents can replace proteins in the diet. The new flour is found to be deficient in carbohydrates so that for ordinary purposes of bread-making it is suggested that ordinary wheat flour be mixed with it in the proper proportion (3—1) to make up this deficiency. The resulting product has now the following composition :—

	Grammes per cent.
Water	6·8
Protein	15·9
Fat	10·3
Carbohydrates	66·0
Ash	1·0

This represents as nearly as possible a " perfect " food, and as such approximates very closely to a patent German food sold in India before the war at Rs. 6 per pound. This flour can be made in India at about one-twenty-fourth of the cost of the German product. If the wheat flour is not added, the new flour makes a valuable food for invalids and for patients suffering from diabetes and allied conditions.

Bread made from the new flour has been subjected to analysis, and sent out for trial. The results of these trials are very encouraging, as the bread is described as pleasant to the taste, easily manipulated, and possessing good keeping qualities.

The above account represents an attempt to bring forward evidence to show the possibilities of great improvement in the

groundnut industry. Not only can the production of Arachis oil be improved, but the resulting groundnut cake has a very high food value. The paper-like husks serve an useful purpose for stuffing mattresses and cushions, and also as a possible source of cellulose (55 per cent.) for paper-making, or as a source of fuel. The thin brown coating over the kernel may be used for manure, as also the ashes from the shells, if these are used as fuel. The leaves and branches of the plant form excellent fodder for cattle, and the groundnut cake also is a valuable cattle food. From the above account it will be seen that there is absolutely no waste in the groundnut industry, and for the oil alone the commercial value is great.

Now that the export trade is cut off, there should be a great demand for this oil in India as a substitute for olive oil, and there are several oil-crushing mills in this country capable of carrying it out. A glance at the figures of the Indian export trade before the war shows in what large quantities these oil-yielding nuts left the country. With the German sources of supply cut off by reason of our acquisition of most of their colonies in Africa, practically the whole trade in oil-containing seeds rests in the hands of the British Empire and America, two great allies. The whole groundnut industry in India has therefore a great future if properly worked, well supervised, and advantage taken of the means of utilizing all the various by-products.

For further details the reader may be referred to *Handbook of Commercial Products, Indian Section, no.* 24, Calcutta, 1893; *The Commercial Products of India,* 1908, *Sir George Watt*; Article in *Indian Journal of Medical Research,* volume IV, no. 4, April 1917, page 786.*

All inquiries on this subject should be addressed to the Secretary, Indigenous Industries Committee, Secretariat, Bombay.

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A NEW CANE DISEASE.

A NEW cane disease is stated to have broken out in Porto Rico the last three seasons and to be spreading steadily. The one noteworthy and constant symptom is the peculiar mottling of the leaves,

* This article was reproduced in the *Agricultural Journal of India,* vol. XII, pt. III, p. 621.

which are marked with numerous white or yellow spots and stripes with irregular indefinite margin ; a comparison is in fact suggested with the Sereh disease, though the two do not correspond in detail. It has been found that the cuttings from affected canes invariably reproduce the disease, no matter how they are treated, or in what soil planted. The effect on the canes varies from reduced yields to total failure of the crop, while the resulting juice is liable to cause a good deal of trouble in the factory. No ordinary cane disease remedies have had any effect, and rotation of crops is advocated as a temporary expedient.—[The *International Sugar Journal*, November, 1917.]

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THE NITRATE POSITION.

We were not far out in surmising that the recent sale of German stocks in Chili would soon be followed by others of the same kind, for, according to a cablegram from Valparaiso, the German oficinas are making preparations for the immediate resumption of production, their output capacity being over 400,000 tons per annum, and the acquisition of new grounds enabling many native and English companies to increase their output. The total in Chili in the current nitrate year ending June 30, 1918, will exceed the record figure of 63,209,000 quintals reached in the preceding twelve-month. The largest annual total before the war in 1913-14 was 62,323,000 quintals (2,833,000 tons), suddenly reduced to 33½ million quintals in 1914-15 through the outbreak of hostilities in Europe and the temporary shutting down of most of the works on the West Coast of South America. The principal agricultural outlets for nitrate of soda were closed, but, thanks to the enormous demand for the article for munition-making, the void was filled, and, notwithstanding scarcity of tonnage, shipments have been on a commensurate scale. Stocks in Chili amount, however, as stated in our last issue, to about 900,000 tons, compared with 750,000 tons at October 1, 1913, the corresponding period before the world was turned topsy-turvy. It may be taken for granted that the Allies, especially the United States, will for some months to come make large purchases of nitrate

without looking too closely at the price ; it is equally certain that "after the war" the European countries will be anxious to restore fertility to their impoverished lands by a free use of artificial manures, among which nitrate of soda has hitherto deservedly taken a prominent part. The question is whether the farmer will be willing to pay the extraordinarily high prices to which the Chilean fertilizer has been pushed, partly by big freights and marine insurance premiums, partly by increased cost of production and the claim to exorbitant profits by producers ; these latter, suffering from "swelled head" through free sales to lavish Government buyers, seem to think that there is no limit to the value of their product, and within the last four months they have had the assurance to raise the f.o.b. price by about six shillings per quintal to 15*s.* 6*d.*, or double that gladly accepted in normal times. As already stated in these columns, the cost of production has undoubtedly risen through higher wages, dearer fuel, bags, and all oficina requirements, the appreciation of the Chilean currency being also an unfavourable factor; but to nothing like an extent justifying so colossal an advance in selling prices, more especially in the face of heavy stocks and uncertain market prospects. Although tonnage cannot be plentiful for some time after the cessation of hostilities, shiproom will eventually be obtainable on easier terms, and rates of insurance will come down with a run ; but unless values in Chili are also materially reduced, nitrate of soda will with difficulty compete successfully with its numerous rivals. The article on "Synthetic Nitrates," now appearing in this journal, sufficiently demonstrates the danger from that quarter, and the British farmer at all events is not likely to invest in the foreign fertilizer at 28*s.* (or more) per cwt. when, thanks to the Government, he can buy the richer home product—sulphate of ammonia—at sixteen shillings. The darkest "nigger in the fence" is probably and, perchance, appropriately of Teutonic origin, it being doubtful whether Germany, hitherto Chili's best customer, will resume her purchases of nitrate after the war, the following words from a recent speech of the Imperial Chancellor being, to say the least, ominous : "There are two matters of great moment to which I should like specially to allude. We

have had to import nitrate from Chili and pyrites from Spain for practically every ton of essential nitrates that we require. I have good hope of the schemes which are at present in hand for the use of gas works ammonia and for the production of cyanide, as well as otherwise for obtaining nitrogen. Germany has produced her nitrates without a ton from Chili." We leave it at that, merely opining that the nitrate outlook is somewhat opaque.—[The *Chemical Trade Journal and Chemical Engineer*, dated Oct. 20, 1917.]

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PHYSIOLOGICAL EFFECT ON GROWTH AND REPRODUCTION OF RATIONS BALANCED FROM RESTRICTED SOURCES.

THE *Journal of Agricultural Research* (vol. X, no. 4) contains a further important contribution by E. B. Hart, E. V. McCollum, and other colleagues to the question of the physiological effect on growth and reproduction of rations balanced from restricted sources. Previous work has indicated that a ration can be complete and efficient only when it contains protein of adequate quantity and quality, adequate energy, mineral ingredients in proper quantity and proportion, and two factors (vitamines) of unknown constitution which have been temporarily designated as "fat-soluble A" and "water-soluble B." Later work now indicates that to these must be added the important factor of direct toxicity. This can be wholly absent or so mild in its effects as to be entirely obscured when the other essentials of a ration are at an optimum adjustment; or with fair adjustment it may only reveal its effects when the ration is continued over a very long time and the animal involved in the extra strains of reproduction and milk secretion. Rations composed exclusively of wheat products (grain and straw) did not sustain growth with Holstein heifers. Such animals also failed to show œstrus and could not be bred. Marked pathological conditions resulted, such as blindness, feeble and emaciated condition, and abnormal excitability followed by collapse. The responsibility was found to be due in part to the inadequate salt mixture provided by the ration, and in part to inherent toxicity in the grain. By the use of maize stover or alfalfa hay as roughage in place of the

wheat straw growth was sustained, but reproduction was only partially successful, weakness commonly appearing in the second gestation. Maize grain *plus* wheat straw allowed sustained growth, but at a slow rate. Additions of salts to this ration made it normal. Addition of wheat embryo to a maize ration caused disturbances, bringing about early abortions, thus indicating a high content of the toxic material in the wheat kernel.—[*Nature*, 6th December, 1917.]

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PROHIBITION, REGULATION, AND RESTRICTION OF IMPORT INTO BRITISH INDIA OF CERTAIN PLANTS AND SEEDS.

THE following notification, dated 7th November, 1917, has been issued by the Government of India in the Revenue and Agriculture Department :—

No. 13-C.—In exercise of the powers conferred by section 3, sub-section (*i*) of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor-General in Council is pleased to issue the following order for the purpose of prohibiting, regulating, and restricting the import into British India of the articles hereinafter specified.

1. In this order :—

(*i*) "official certificate" means a certificate granted by the proper officer or authority in the country of origin ; and the officers and authorities named in the third column of the Schedule are the proper officers and authorities to grant in the countries named in the second column the certificates required by the provisions referred to in the first column thereof ;

"plant" means a living plant or part thereof but does not include seeds ; and

"prescribed port" means any of the following ports, namely, Bombay, Calcutta, Dhaneshkodi, Karachi, Madras, Negapatam, Rangoon, and Tuticorin ;

(*ii*) all provisions referring to plants or seeds shall apply also to all packing material used in packing or wrapping such plants or seeds.

2. No plant shall be imported into British India by land or sea by means of the letter or sample post.

3. No plants other than fruits and vegetables intended for consumption, potatoes and sugarcane shall be imported into British India by sea except after fumigation with hydrocyanic acid gas and at a prescribed port:

Provided that plants which are infested with living parasitized insects and are intended for the introduction of such parasites may be imported without such fumigation if they are accompanied by a special certificate from the Imperial Entomologist to the Government of India that such plants are imported for the purpose of introducing such parasites.

4. Potatoes shall not be imported into British India by sea, unless they are accompanied by—

(*i*) a certificate from the consignor stating fully in what country and in what district of such country the potatoes were grown and guaranteeing that warty disease was not known to exist on the farms where the potatoes were grown; and

(*ii*) an official certificate that no case of warty disease of potatoes has been known during the twelve months preceding the date of the certificate within five miles of the place where the potatoes were grown.

5. Rubber plants shall not be imported into British India by sea unless they are accompanied by an official certificate that the estate from which the plants have originated or the individual plants are free from *Fomes semitostus* and *Sphārostilbe repens*.

6. Sugarcane shall not be imported into British India by sea unless it is accompanied by an official certificate that it has been examined and found free from cane borers, scale insects, Aleurodes, root disease (any form), pine-apple disease (*Thielaviopsis ethaceticus*), "Sereh" and cane gummosis:

Provided that canes for planting intended to be grown under the personal supervision of the Government Sugarcane Expert, may be imported direct by such expert without such certificate.

7. Coffee plants shall not be imported into British India by sea from America (including the West Indies) except by the Madras Department of Agriculture.

8. Seeds of coffee, flax, *berseem*, and cotton shall not be imported by land or by sea by letter or sample post.

9. Coffee seeds shall not be imported into British India by sea from America (including the West Indies) except by the Madras Department of Agriculture.

10. Flax seeds and *berseem* (Egyptian clover) seeds shall not be imported into British India by sea, unless the consignee produces before the Collector of Customs a license from a Department of Agriculture in India in that behalf.

11. Cotton seeds shall not be imported by sea except after fumigation with carbon bisulphide and at a prescribed port.

SCHEDULE.

1	2	3
Paragraph	Country of Origin	Authority
4 (*ii*)	Great Britain and Ireland ..	The Board of Agriculture and Fisheries, England. The Board of Agriculture for Scotland. The Department of Agriculture and Technical Instruction for Ireland.
	Sweden	The Ministry of Agriculture.
	Norway	The Norwegian Board of Agriculture.
	Denmark	The Ministry of Agriculture.
	France	The Ministry of Agriculture.
	Japan (including Formosa) ..	The Department of Agriculture and Commerce.
	Italy	The Ministry of Agriculture.
	British East Africa ..	The Department of Agriculture.
	Australia	The Departments of Agriculture, Victoria, South Australia, New South Wales, Queensland, Tasmania, and Western Australia.
5	Ceylon	The Department of Agriculture.
	Malay Peninsula ..	The Department of Agriculture, Federated Malay States.
	Dutch Indies	The Department of Agriculture, Industry and Commerce.
	Belgian Congo	The Department of Agriculture.
	British East Africa ..	The Department of Agriculture.
	Uganda Protectorate ..	The Department of Agriculture.
	Nyassaland	The Department of Agriculture.
	South Africa	The Union of South Africa Department of Agriculture.
6	Dutch Indies	The Department of Agriculture, Industry and Commerce.
	Mauritius	The Department of Agriculture.
	Philippine Islands ..	The Bureau of Agriculture.

SCHEDULE.—(*Continued.*)

1	2	3
Paragraph	Country of Origin	Authority
	Japan (including Formosa) ..	The Department of Agriculture and Commerce.
	South Africa	The Union of South Africa Department of Agriculture.
	Egypt	The Ministry of Agriculture.
	West Indies	The Imperial Department of Agriculture, Barbados.
	British Guiana	The Department of Science and Agriculture.
	Trinidad	The Department of Agriculture.
	Jamaica	The Department of Agriculture.
	United States	The Department of Agriculture.
	Ceylon	The Department of Agriculture.
	Malay Peninsula ..	The Department of Agriculture, Federated Malay States.
	British East Africa ..	The Department of Agriculture.
	Queensland	The Department of Agriculture and Stock.

* * *

Government of India, Department of Revenue and Agriculture, Notification No. 215-*C. dated the* 8*th February*, 1918.

In exercise of the powers conferred by section 3, sub-section (*i*) of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor-General in Council is pleased to direct that the following proviso be added at the end of clause 2 of the order issued with the Department of Revenue and Agriculture Notification No. 13-C, dated the 7th November, 1917 :—

" Provided that sugarcane for planting intended to be grown under the personal supervision of the Government Sugarcane Expert may be imported by him by such post."

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

The following honours in the New Year's List will be of interest to the members of the Indian Agricultural Service :—

K.C.S.I. Mr. F. G. Sly, I.C.S., C.S.I., at one time Officiating Inspector-General of Agriculture.

C.S.I. The Hon'ble Mr. C. E. A. W. Oldham, I.C.S., formerly Director of Agriculture, Bengal ; and Mr. L. J. Kershaw, C.I.E., formerly Secretary, Revenue and Agriculture Department, Government of India.

C.I.E. Mr. A. Langley, I.C.S., formerly Registrar of Co-operative Societies, Punjab.

To all these gentlemen we offer our hearty congratulations.

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Mr. M. Wynne Sayer, B.A., Assistant to the Agricultural Adviser to the Government of India, is with effect from the forenoon of the 6th February, 1918, placed in charge of the work of the Imperial Agriculturist in addition to his own duties during the absence on deputation to Mesopotamia of Mr. G. S. Henderson, N.D.A., N.D.D., Officiating Imperial Agriculturist, or until further orders.

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Mr. Daulat Ram Sethi, M.A., B.Sc., Deputy Director of Agriculture in charge of the Orissa Circle, is confirmed in the Indian Agricultural Service with effect from the afternoon of the 30th October, 1917.

This officer was granted privilege leave for one month from the 13th December, 1917.

Mr. N. S. McGowan, Professor of Agriculture, Sabour College, has been granted combined leave for one year with effect from 2nd February, 1918, or any subsequent date on which he may avail himself of it.

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Mr. A. W. Fremantle, Special Officer in charge of Ravine Reclamation, United Provinces, has been granted extraordinary leave without allowances for two months in continuation of that already granted to him.

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Mr. G. Evans, M.A., Deputy Director of Agriculture, Northern Circle, Central Provinces, has joined the Indian Army Reserve of Officers with the rank of Temporary Captain. He has been placed on recruiting duty.

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Mr. D. Balakrishna Murti, Assistant Director of Agriculture, First Circle, Madras Presidency, was granted privilege leave for three months from or after 15th January, 1918, Mr. S. V. Thirumuruganatha Pillai acting in his place.

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Mr. A. L. Sheather, B.Sc., M.R.C.V.S., Director and First Bacteriologist, Muktesar Laboratory, is confirmed in his appointment with effect from the 4th October, 1917.

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Mr. S. G. M. Hickey, M.R.C.V.S., 2nd Superintendent, Civil Veterinary Department, United Provinces, is confirmed in the Civil Veterinary Department.

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Mr. H. E. Cross, M.R.C.V.S., D.V.H., A.Sc., Civil Veterinary Department, on reversion from military duty, was granted combined leave for six months with effect from the afternoon of 1st September, 1917.

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Mr. W. A. Pool, M.R.C.V.S., is confirmed in the Civil Veterinary Department with effect from the 27th December, 1917.

In Memoriam.

The Late Mr. C. W. MASON,
Formerly Supernumerary Entomologist, Pusa.

Mr. Jadeo Singh Garewal has been appointed to the Indian Civil Veterinary Department with effect from 29th January, 1918, and is posted to the Punjab for training.

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The three new Assistant Professors recently sanctioned by Government for the Agricultural College at Lyallpur have all assumed charge of their duties.

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IN MEMORIAM.

We regret to announce the death of Mr. Charles William Mason, which occurred on 28th November, 1917, at Zomba, Nyassaland, as the result of blackwater fever. Mr. Mason was born on 13th May, 1884, and, after eight years at Conyngham House School, Ramsgate, and Haileybury College, spent three years at the South-Eastern Agricultural College, Wye, where he passed both parts of the College Diploma and also gained the Botany prize in 1905 and a silver medal for the best entomological and botanical collections. In October 1906, Mr. Mason was appointed to the Indian Agricultural Service as a Supernumerary Entomologist, and in December arrived at Pusa, where he was stationed until January 1910, when he returned to England on termination of his agreement.

During his service in India he was chiefly occupied in an investigation of the food of birds, especially in relation to the value of birds to agriculture by their destruction of insect pests, and the third volume of the Entomological Memoirs of this Department is wholly devoted to a record of this work.

After his return to England in 1910 he studied for some time at the South-Eastern Agricultural College at Wye, and afterwards went to America as a Carnegie student to undergo further training in entomology. Subsequently he was appointed to succeed Mr. E. Ballard as Government Entomologist in Nyassaland.

He leaves many who will remember him as a cheerful and honest worker, an all-round athlete, and a good friend.

Reviews.

Plant Types for College Students.—By Father Ethelbert Blatter, S. J., Professor of Botany, St. Xavier's College, Bombay. Published by the Author. Price R. 1-8.

Father Blatter has previously done excellent service to the cause of science by the production of text-books suitable for university and college students. He now comes forward with a book on the plant types prescribed for the science courses of the Bombay University. This little volume will save the student a great deal of reference to many larger works, and at the same time it does not in any way take from the student the work of observation and enquiry. Illustrations have been deliberately omitted in order that the student may make his own drawings. The book really takes the place of an expert demonstrator who tells the student what to look for and leaves him to find the things mentioned.

Short historical and economic notes on the various plants serve to link up the more purely botanical matter with general knowledge and common life. The study of types is a method of teaching of comparatively recent origin, and has much to recommend it. The student studies intensively a few plants, and is taught rigid accuracy of observation and completeness of analysis of these few typical plants. The result is a training in method which can be applied at will to any other plant or problem. No one claims that it is the only method, but it is a very necessary part of a sound biological training. The volume under review is a most useful aid in the application of this method.—[W. B.]

The Agricultural Problems of India.—By Rai Bahadur Ganga Ram, C.I.E., M.V.O. Simla Art Press.

Rai Bahadur Ganga Ram, late of the P. W. D. and now a big zemindar on new Canal Colony land in the Punjab, has written a thoughtful work which will be read with interest by many who are connected with agriculture in India. The book consists of 60 pages, dealing generally with the subjects of poverty, famine, land revenue, irrigation, and agriculture. As an appendix there is a mass of tables taken from revenue and irrigation reports: some of these will doubtless be useful to seekers after knowledge.

Among some of the novel ideas are "the abolition of the present land revenue system and the substitution of a produce tax of $\frac{1}{6}$th of all produce of the land, the duty to be charged on all produce brought to the railway station"; and "that exemption from land revenue might be bought by any landowner for a cash payment of 30 years' tax, the money so obtained to be paid into Indian banks, the banks to pay the Government revenue from the interest, and use the principal to finance Indian industries."

The author does not, however, tell us from what source the huge sums necessary to redeem the tax are to be produced by the zemindar. There are not many parts of India, except Canal Colonies, where money is plentiful.—[G. S. H.]

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All about the Mango.—By V. R. Gadgil, B.Ag., 241, Sadashiv Peth, Poona. Price As. 12.

This little book is the first of a series in Marathi, dealing with the important fruit crops of India which the author contemplates to bring out. It contains a concise summary of the most important facts about the propagation and cultivation and diseases of the mango. Numerous references to current literature in India and elsewhere, and a bibliography, are given and bear testimony to the pains the author has taken to bring the book up to date. A detailed calendar of the operations to be carried out on a mango plantation from month to month, given at the end of the book, greatly adds to its practical utility.—[S. L. A.]

Correspondence.

To the Editor,

The Agricultural Journal of India.

Sir,

Lord Willingdon in his interesting article on the Ganeshkhind Dairy Herd (vol. XIII, no. 1) makes the recommendation that young stock should never be tied up. I suppose breeds differ considerably in their docility, but it is more general opinion in my experience that unless an animal has been used to tying and the handling it entails, she is likely to be unruly when brought into the herd, and that it is better to accustom them to this at an early age. Perhaps others could give their experience on this rather important point.

Coimbatore :
January 27, 1918.

Yours faithfully,
R. Cecil Wood.

To the Editor,

The Agricultural Journal of India.

Sir,

In your issue of October last my friend Mr. W. Roberts of Lyallpur, in the first instalment of the account of his recent visit to Egypt, America, etc., makes a reference to me, which, I think, calls for a brief reply. Mr. Roberts is speaking of the relative density of cotton bales in India, America, and Egypt, that in India being the highest, and goes on to say, " In this connection, ' The

World's Cotton Crops' by Professor Todd, page 126, may be consulted from which a different impression is gathered." Knowing that I had never expressed any opinion about the Indian bale, I turned to the page in question, to find that it deals exclusively with the comparative merits of the American and Egyptian systems of handling the crop throughout from the field to the ship's side. The question of baling is only one part of that system, and the mention of the fact that the Egyptian bale possessed a much higher density than the American bale was not in the least intended to convey, and I think would not convey, any comparison of either with the Indian bale.

All that I said elsewhere in the book about the Indian bale is on page 40 as follows: "It is well pressed, the exact density given varying according to the destination of the bales. Those for Europe are most heavily pressed."

Yours faithfully,
JOHN A. TODD.

NOTTINGHAM:
November 12, 1917.

TO THE EDITOR,

The Agricultural Journal of India.

SIR,

In submitting the attached letter which appeared in the *Times of India* for publication in the *Agricultural Journal of India*, I should be pleased if in view of your invitation for criticisms you would allow me to make a few comments on the article "The Problem of Sugar Manufacture in India" which appeared in the last October issue of the *Journal.** It is stated that "the main point is that even with the existing varieties and the present low yields of cane per acre it is possible to make the industry more

* Vol. XII, pt. IV, p. 550.

remunerative to the cultivator, to increase the supply of *gur*, and make more raw sugar available in this country for refining."

In a paper on "The Sugar Industry" submitted to the XIth Industrial Conference held in Bombay in December 1915, the writer clearly showed that the refining of cane *gur* was not the method to employ to make sugar manufacture a financial success and that cane *gur* should only be made for consumption in that state.

To the attempts to manufacture sugar profitably by refining cane *gur* is chiefly due the backward state of the sugar industry in this country, as the process is against all the principles of economics, for it must be evident that unless a refinery can purchase a superior quality of cane *gur* at a cheap rate, when normal prices of sugar prevail, it will not pay to refine it on account of the enormous wastage and the high cost of refining, and if the ryot has to sell his *gur* at a cheap rate to a refinery which allows him little or no profit, he has no inducement to grow cane or make *gur*.

Where there is no cane sugar factory to which the ryot can send his cane, which can afford to pay him a price that will give him a reasonable profit through manufacturing sugar by the direct process, he must confine himself to making *gur* in the most economical manner possible for the *gur*-eating market, but he cannot be expected to be able to purchase and employ for this purpose such machinery as is used in large cane sugar factories for the simple reasons that he has not the capital, neither could he work the machinery if he had it, even if he had the large area of cane required to keep such plant as steam mills with Krajewski crushers and Triple Effect evaporators continuously at work during the cane season. For making *gur* the ryot having, say, 100 acres of cultivation cannot do better than employ crushing mills driven by oil-engines, and juice-boiling pans in which the juice would be boiled rapidly to the desired consistency, as the employing of steam boilers and engines would necessitate the employing also of a mechanic holding a certificate under the Boiler Act, which it is very doubtful if the average ryot is prepared to do.

The co-operation of several ryots is entirely another matter, for such co-operation would be equivalent to the forming of a

company to establish a factory which would deal with the cane from each of their holdings, and it is very doubtful for obvious reasons if it would be a success, unless it was under European management.

For the average ryot it would seem, therefore, that the method recommended above and as employed at the Manjri Farm cannot be improved on, unless a more rapid juice-boiling pan were to be employed of the tubular type such as established very successfully by the writer about ten years ago in the Madras Presidency. This rapid juice-boiling pan was made locally and used as an evaporator, the ordinary juice-boiling pans being used for finishing the boiling. The result was a good light-coloured jaggery or *gur* which fetched a good price in the *gur*-eating market.

In order to develop the sugar industry of the country the idea of refining cane *gur* must be given up. It is quite a different thing to refine the jaggery made from the palmyra tree juice which can be purchased cheaply owing to there being no cost for cultivating. This jaggery is largely used for refining purposes in the large refineries in the Madras Presidency to which the writer was attached for five years, but the large quantity of molasses produced in refining this jaggery necessitates the business becoming a distilling business as well, otherwise the refinery would not pay. The cane sugar manufacturing side of this refinery has been considerably developed within recent years, white sugar being turned out without using animal char the employment of which becomes necessary if a white sugar is to be obtained from *gur* or jaggery, thus increasing the cost of production.

As correctly pointed out in "The Problem of Sugar Manufacture in India," the most urgent reform required is on the manufacturing side, and there is no place in the whole of India more suitable for developing the sugar industry on a large scale than the Bombay Deccan, if only the land could be obtained.

CUMBALLA HILL: BOMBAY,
December 29, 1917.

Yours faithfully,
A. E. JORDAN.

Letter dated 26th December, 1917, by Mr. Jordan to the editor of the *Times of India* :—

In the written evidence submitted by the Indian Merchants Chamber to the Industrial Commission the following suggestion occurs :

" (*b*) If sugar cultivation is to spread and the sugar industry to become successful the Abkari system must be changed.

" The utilization of molasses is necessary if a sugar factory is to work at a profit. Rum should, therefore, be allowed to be manufactured from the molasses. Unless this concession is granted a sugar factory is not likely to prove a success financially."

There can be no question that it is more profitable for a sugar factory to have a distillery attached to it in order to convert the exhausted molasses into spirit, but if the cane sugar industry is to be developed on a large scale in the Bombay Presidency, as it must be, for India to become self-contained in the matter of sugar production and even an exporting country, it may not be practicable, or even advisable, for a distillery to be attached to every sugar factory it is proposed to establish.

In view of the evidence submitted by the Indian Merchants Chamber it may, therefore, interest its members who take an interest in the important industry to know that a sugar factory can be financially successful even without a distillery if the factory be of the proper kind.

The correctness of this statement by the writer who claims to be an expert in sugar factory design and in sugar manufacture, is borne out by the following :—

There are two types of sugar factories—the first a cane sugar factory which manufactures white sugar by the direct process from the cane and which utilizes the refuse crushed cane as fuel for generating the steam necessary to run the factory, thus producing the maximum quantity of sugar and the minimum of molasses at the minimum cost of production ; the second is a sugar refinery which manufactures sugar by refining the *gur*, or raw sugar, made by the ryots, from which only about 40 per cent. and frequently less of marketable sugar is obtained and to obtain which coal has to be

used as fuel, thus producing the minimum quantity of sugar and the maximum quantity of molasses at the maximum cost of production.

The former type of sugar factory, if properly designed, erected in the proper place, and efficiently managed, can be a financial success without a distillery; while the latter type of raw sugar refinery cannot be a financial success unless it has a distillery attached to it for converting the large quantity of molasses produced into spirit and this has been fully demonstrated by the number of such concerns that have been obliged to close in different parts of the country.

In "The Problem of Sugar Manufacture in India" by the Assistant to the Agricultural Adviser to the Government of India which appears in the last October number of the *Agricultural Journal of India*, it is stated, "as a matter of fact the factory at Pilibhit and the sugar factories in Bihar were running successfully even before the war. . . . . At present we import 61 lakhs of rupees worth of molasses, the by-product of sugar factories, and large quantities of molasscuit which is a cattle food prepared from molasses.

"If more sugar factories be opened in India they will be able to meet this demand and a license to manufacture rum will not be essential if steps are taken to develop the use of these by-products within the country itself."

The factories referred to are cane sugar factories of the first mentioned type and have no distilleries attached to them. It is also the case that in Mauritius, an island of about 750 square miles in area, there are about 60 cane sugar factories working on similar lines, run by Indian labour, and turning out 200,000 tons of sugar per season of five months, and none of these factories have distilleries attached to them, with the exception of one which manufactures a spirit for lighting purposes.

It would seem, therefore, once the necessary legislation is carried out which will enable the land to be acquired, that there is no reason why the Bombay-Deccan where such favourable conditions for cane cultivation prevail should not become a Mauritius or a

Java as far as the production of sugar is concerned, as Bombay possesses Marwaris and other capitalists bursting with money for which they require new fields of investment.

Notwithstanding the fact that a cane sugar factory can be financially successful without a distillery, yet for the development of the sugar industry in the Bombay Presidency it becomes advisable that the first factory to be established, or even a second, should have a distillery attached to it, to which the exhausted molasses from the cane sugar factories to be erected later could be sent instead of the country having to import molasses to the extent of 61 lakhs from Mauritius and Java for the purpose of manufacturing spirit in India.

To the Editor,

The Agricultural Journal of India.

Sir,

With reference to Mr. Jordan's letters, printed above, on the article entitled "The Problem of Sugar Manufacture in India," which appeared in the October (1917) Number of your *Journal*, I should like to make the following observations, taking his criticisms in order.

He criticizes the following sentence in my article : "The main point is that even with the existing varieties and the present low yields of cane per acre it is possible to make the industry more remunerative to the cultivator, to increase the supply of *gur*, and make more raw sugar available in this country for refining." This sentence has been taken from a paragraph in the article which emphasizes the absolute necessity for putting a stop to the enormous wastage—some 30 to 50 per cent.—which now goes on in *gur*-making.

Any improvement in this line will increase the *gur* production ; part of this may take the place of the molasses now imported from Java ; the rest will tend to glut the *gur* market and will make more *gur* available for refining.

In the case of surplus *gur*, refining is Hobson's choice.

Another point which has, I think, escaped Mr. Jordan's notice is the fact that in the Eastern parts of the United Provinces and Bihar which produce much *gur*, the product does not rank as eating *gur* but is only suitable for refining. Hence it sells for Rs. 2-8 per maund in average years.

The use of improved methods of *gur* boiling makes for a larger recovery of sugar when we come to refine. The low recovery at present is due to the caramelization which takes place in the open pan. This can be prevented to a great extent in an up-to-date *gur* factory.

It will thus be seen that the contention maintained in the article is that if the losses taking place in the mechanical part of the process are cut it will mean not only more income to the ryot but also a large increase in the out-turn of sugar and a consequent reduction in the imports from abroad.

The manufacture of white sugar direct from the cane has always been advocated in those areas where the supply of cane is constant and the quantity sufficient to supply a central factory economically, but in tracts where the cultivation is not concentrated *gur* must be made first irrespective of the fact whether it is eaten or refined afterwards, and if the cane cultivation cannot carry a *gur* factory then the Manjri system or other improvements advocated by the Agricultural Department can be employed.

With regard to the question of steam plant *versus* oil, which Mr. Jordan raises, comment is hardly necessary. The simple fact that the steam plant runs on megass and the oil plant requires fuel from a distance is, I think, conclusive. The present price of oil will soon shut down most oil-driven plants which work on a small margin, and there is no comparison between the difficulties of getting cheap oil and a boiler certificate.

I would also point out that nowhere in my article is the ryot recommended to run his own manufacturing plant. It should only be as a last resort in those areas where cultivation is so scattered as to make any other arrangements unworkable.

The following cuttings make interesting reading and, I think, bear out further what is maintained in my article.

The report of the Cawnpore Sugar Works for the year ending December 31st, 1917, is a very satisfactory one. Notwithstanding unfavourable results at both the company's distilleries a profit has been earned of Rs. 8,26,281 which enables dividend and bonus to be distributed on the ordinary shares at the rate of 35 per cent. While the war lasts Indian sugar companies should do well, since the imports of foreign sugar are restricted.

The report of the Champaran Sugar Company, Limited, for the year ended 30th June, 1917, shows a profit, after providing for commissions, bonus to cane-growers, and taxes, of Rs. 2,48,319-11-10, including Rs. 12,756-3-10 carried forward from previous year. The Directors recommend that Rs. 30,000 be placed to the Depreciation Fund, Rs. 75,000 be transferred to the Reserve Fund, Rs. 48,000 be spent in payment of dividend at the rate of Rs. 8 per share (Rs. 100), Rs. 72,000 be spent in payment of a bonus of Rs. 12 per share, and Rs. 23,319-11-10 be carried forward. 24,000 tons of canes were treated during the season as compared with 16,404 tons during the preceding year. The crop yield was 9·3 tons per acre, which, although better than the previous year's yield, was much below the average owing to unfavourable weather conditions.

The report of the Ryam Sugar Co., Ltd., for the year ended 30th June, 1917, shows a profit of Rs. 1,79,491-11-7, after providing for debenture interest, commissions, and taxes. The Directors after proposing to transfer Rs. 75,000 to the Reserve Fund recommend a dividend of Rs. 8 and a bonus of Rs. 2 per cent. ; Rs. 13,685-0-7 will be carried forward to next year's account. Manufacturing results show an improvement on the previous season and satisfactory results have been realized for the Company's manufactures.

PUSA :
February 21, 1918.

Yours faithfully,
WYNNE SAYER.

NEW BOOKS.

1. The Wheat Problem, by Sir W. Crookes. Third Edition, with Preface, and an Additional Chapter, bringing the Statistical Information up to date, and a Chapter on Future Wheat Supplies, by Sir R. H. Rew. Pp. xvi+100. (London : Longmans & Co.) Price 3*s*. 6*d*. net.

2. The Chemical Constitution of the Proteins, by Dr. R. H. A. Plimmer. In three parts. Part I., Analysis. Third Edition. Pp. xii+174. (London : Longmans & Co.) Price 6*s*. net.

3. A Handbook of Nature Study and Simple Agricultural Teaching for the Primary Schools of Burma, by E. Thompstone, B. Sc. Pp. xi+279. With 115 Illustrations. (Longmans, Green & Co.)

4. Organic Evolution, by Prof. R. S. Lull. Pp. xviii+729. (New York : The Macmillan Co. ; London : Macmillan & Co., Ltd.) Price 3 dollars.

5. The Anatomy of Woody Plants, by E. C. Jeffery. Pp. x + 478. (Chicago : University of Chicago Press ; London : Cambridge University Press.) Price 4 dollars net.

6. A Dictionary of Applied Chemistry, by Sir Edward Thorpe. New Edition. Thoroughly Revised and much Enlarged. In five volumes. Price 50*s*. net each.

7. An Introduction to the Chemistry of Plant Products, by Paul Haas and T. G. Hill. Second Edition. With Diagrams. Price 10*s*. 6*d*. net.

8. Vegetable Forcing, by R. L. Watts. Pp. xx + 431. (New York : Orange Judd & Co.) Price 2 dollars net.

9. The Chemistry of Linseed Oil, by J. Newton Friend. Pp. vii+96. (London : Gurney & Jackson.) Price 2*s*. 6*d*. net.

10. Cotton and other Vegetable Fibres : Their Production and Utilization, by Ernest Goulding. (London : John Murray.) Price 6*s*. net.

11. Manuring for Higher Crop Production, by E. J. Russell. (Cambridge University Press.) Price 3*s*. 6*d*. net.

12. Biology, by Prof. G. N. Calkins. Second Edition. Pp. viii+255. (New York : H. Holt & Co.)

13. The Study of Animal Life, by Prof. J. A. Thomson. Revised Edition. Pp. xvi+477. (London : John Murray.) Price 6*s*. net.

14. The Pasteurization of Milk from the Practical View Point, by C. H. Kilbourne. Pp. iv+248. (New York : J. Wiley and Sons, Inc. ; London : Chapman and Hall, Ltd.) Price 6*s*. net.

15. Modern Propagation of Tree Fruits, by Prof. B. S. Brown. Pp. xi+174. (New York : J. Wiley and Sons, Inc. ; London : Chapman and Hall, Ltd.) Price 6*s*. net.

16. Dairy Cattle Feeding and Management, by Prof. C. W. Larson and F. S. Putney. Pp. xx+471. (New York : J. Wiley and Sons, Inc. ; London : Chapman and Hall, Ltd.) Price 11*s*. 6*d*. net.

17. The Faith of a Farmer : Extracts from the Diary of William Dannatt, of Great Waltham. Edited with an Introduction by J. E. G. de Montmorency. Pp. xliii+249. (London : J. Murray.) Price 5*s*. net.

18. British Grasses and their Employment in Agriculture, by S. F. Armstrong. Pp. vii+199. (Cambridge University Press.) Price 6*s*. net.

19. Science and Education, Edited with an Introduction by Sir Ray Lankester, K. C. B. (London : William Heinemann.) Pp. 200. Price 1*s*.

20. Artificial Dye-Stuffs: Their Nature, Manufacture, and Uses, by A. R. J. Ramsey and H. C. Weston. Pp. ix+212. (London: G. Routledge and Sons, Ltd.) Price 3*s*. 6*d*. net.

21. A Critical Revision of the Genus Eucalyptus, by J. H. Maiden. Vol. IV, Part 1. (Sydney: W. A. Gullick.) Price 2*s*. 6*d*.

22. The Exploitation of Plants, Edited by Prof. F. W. Oliver. (London: J. M. Dent & Sons, Ltd.) Price 2*s*. 6*d*. net.

23. Histology of Medicinal Plants, by Prof. W. Mansfield. Pp. xi+305. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.). Price 13*s*. 6*d*. net.

24. Practical Cheese-making, by C. W. Walker Tisdale and W. E. Woodnutt. Pp. 182. (London: Headley Bros., Ltd.) Price 4*s*. 6*d*. net.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. The Inheritance of Characters in Rice, I, by F. R. Parnell, B.A.; G. N. Rangaswami Ayyangar, B.A.; and K. Ramiah, L.Ag. (Botanical Series, Vol. IX, No. 2.) Price R. 1-8 or 2*s*.

2. A Bacterial Disease of Wheat in the Punjab, by C. M. Hutchinson, B.A. (Bacteriological Series, Vol. I, No. 7.) Price As. 12 or 1*s*.

Bulletins.

1. Second Report on the Experiments carried out at Pusa to improve the Mulberry Silk Industry, compiled under the direction of the Imperial Entomologist, by M. N. De. (Bulletin No. 74.) Price As. 4 or 5*d*.

2. Smuts of *Jowar* (*Sorghum*) in the Bombay Presidency, by G. S. Kulkarni, L.Ag., Assistant Mycologist, Department of Agriculture, Bombay. Price As. 4 or 5*d*.

3. Indigo Publication No. 1. A Study of the Indigo Soils of Bihar. The urgent necessity of immediate Phosphate manuring if crops are to be maintained, by W. A. Davis, B. Sc., A. C. G. I.

Reports.

1. Report on the Progress of Agriculture in India for the year 1916-17. Price As. 12 or 1*s*. 1*d*.
2. Report of the Proceedings of the Second Entomological Meeting held at Pusa on the 5th-12th February 1917. Price Rs. 3 or 4*s*. 6*d*.
3. Proceedings of the Board of Agriculture in India, held at Poona on the 10th December 1917 and following days (with Appendices). Price As. 13 or 1*s*. 3*d*.
4. Annual Report of the Imperial Bacteriologist, Muktesar Laboratories, for the year ending 31st March 1917. Price As. 5 or 6*d*.

LIST OF AGRICULTURAL PUBLICATIONS IN INDIA FROM 1ST AUGUST, 1917, TO 31ST JANUARY, 1918.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	The *Agricultural Journal of India*, Vol. XII, Part IV, and Vol. XIII, Part I. Price Rs. 2; annual subscription Rs. 6.	Edited by the Agricultural Adviser to the Government of India, Pusa.	Messrs. Thacker, Spink & Co., Calcutta.
2	Scientific Reports of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist), for 1916-17. Price As. 9 or 10*d*.	Issued from the Agricultural Research Institute, Pusa.	Government Printing, India, Calcutta.
3	Report on the Progress of Agriculture in India for 1916-17. Price As. 12 or 1*s*. 1*d*.	Agricultural Adviser to the Government of India, Pusa.	Ditto.
4	Proceedings of the Board of Agriculture in India, held at Poona on the 10th December 1917 and following days (with Appendices). Price As. 13 or 1*s*. 3*d*.	Issued by the Agricultural Adviser to the Government of India, Pusa.	Ditto.
5	Water Hyacinth (*Eichornia crassipes*): Its value as a fertilizer. Bulletin No. 71 of the Pusa Agricultural Research Institute. Price As. 5 or 6*d*.	R. S. Finlow, B.SC., F.I.C., Government Fibre Expert, Bengal; and K. McLean, B.SC., Deputy Director of Agriculture, Eastern Bengal.	Ditto.
6	New Agricultural Implements for India. Bulletin No. 73 of the Pusa Agricultural Research Institute. Price As. 3 or 4*d*.	G. S. Henderson, N.D.A., N.D.D., Offg. Imperial Agriculturist.	Ditto.
7	Annual Report of the Department of Agriculture, Bengal, for the year ending 30th June, 1917. Price As. 5 or 6*d*.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
8	Annual Reports of Expert Officers of the Department of Agriculture, Bengal, for the year ending 30th June, 1917. Price R. 1-6 or 2*s*.	Ditto	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
9	*Dhaincha* green manure. Leaflet No. 3 of 1917 (in English & Bengali).	F. Smith, B.SC., F.H.A.S., M.R.A.S.E., Deputy Director of Agriculture, Western Circle, Bengal.	Department of Agriculture, Bengal.
10	A Note on Water Hyacinth ..	R. S. Finlow, B.SC., F.I.C., Fibre Expert, Bengal.	Ditto.
11	Report on the Crop-Cutting Experiments during the quinquennium from 1912-13 to 1916-17. Price As. 5.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depôt, Calcutta.
12	Annual Report of the Department of Agriculture, Bihar and Orissa, for the year ending 30th June 1917. Price As. 8 or 9*d.*	Issued by the Department of Agriculture, Bihar and Orissa.	Bihar and Orissa Government Press, Patna.
13	Report on the Agricultural Activities of Government in Bihar and Orissa for the year ending 30th June 1917. Price R. 1-6 or 1*s.* 10*d.*	Ditto ..	Ditto.
14	The *Agricultural Journal*, Vol. IV, No. 2 and Vol. V, No. 1 (half-yearly) Subscription R. 1 per annum.	Ditto ..	Ditto.
15	Report on the Administration of the Department of Agriculture of the United Provinces of Agra and Oudh for the year ending 30th June 1917. Price As. 6 or 6*d.*	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
16	Season and Crop Report of the United Provinces of Agra and Oudh for 1916-17. Price As. 8 or 9*d.*	Ditto ..	Ditto.
17	Report on the Agricultural Stations of the Western Circle, United Provinces of Agra and Oudh, for the year ending 30th June 1917. Price As. 8 or 9*d.*	Ditto ..	Ditto.
18	Report on the Experiment Stations in the Central Circle, United Provinces, for the year ending 30th June 1917. Price R. 1-4 or 2*s.*	Ditto ..	Ditto.
19	Manures. Cultivators' pamphlet No. 15.	B. C. Burt, B.SC., Deputy Director of Agriculture, Central Circle, United Provinces.	Ditto.
20	Report on the Government Botanical Gardens, Saharanpur, for the year ending 31st March 1917. Price As. 3 or 4*d.*	Issued by the Department of Agriculture, United Provinces.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
21	Report on the Government Horticultural Gardens, Lucknow, for the year ending 31st March 1917. Price As. 3 or 4*d.*	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
22	Annual Report of the Department of Agriculture, Punjab, for the year ending 30th June 1917. Price R. 1 or 1*s.* 6*d.*	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
23	Season and Crop Report of the Punjab for the year 1916-17. Price As. 12 or 1*s.*	Ditto ..	Ditto.
24	Tables of the Agricultural Statistics of the Punjab for the year 1916-17.	Ditto ..	Ditto.
25	Year Book of the Punjab Agricultural Department for 1916. Price R. 1-4 or 1*s.* 10*d.*	Ditto ..	Ditto.
26	Experiments, etc., at the Agricultural Station, Lyallpur, Punjab, September 1917. Price As. 8.	Professor of Agriculture, Lyallpur.	Ditto.
27	Annual Report of the Department of Agriculture, Bombay Presidency for 1916-17.	Issued by the Department of Agriculture, Bombay.	Government Central Press, Bombay.
28	Season and Crop Report of the Bombay Presidency for 1916-17. Price As. 5 or 6*d.*	Ditto ..	Ditto.
29	The Spice Gardens of Sirsi in Kanara. Bulletin No. 83 of 1917. Price As. 10-6 or 1*s.*	D. L. Sahasrabuddhe, B.SC., L.AG., Assistant Professor of Chemistry, Poona Agricultural College.	Ditto.
30	Note on Cattle in the Bombay Presidency. Bulletin No. 85 of 1917. Price As. 11 or 1*s.*	The Hon'ble Mr. G. F. Keatinge, C.I.E., I.C.S., Director of Agriculture, Bombay.	Ditto.
31	Report on the Operations of the Department of Agriculture, Madras Presidency, for the official year 1916-17.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
32	Report of the Work of Anakapalle Agricultural Station for 1916-17. Price A. 1-6 or 2*d.*	Ditto ..	Ditto.
33	Report of the Work of Taliparamba Agricultural Station for 1916-17. Price 1 anna or 1*d.*	Ditto ..	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		General Agriculture—contd.	
34	Report of the Work of Samalkota Agricultural Station for 1916-17. Price As. 2 or 2*d.*	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
35	Report of the Work of Palur Agricultural Station for 1916-17. Price As. 3 or 3*d.*	Ditto ..	Ditto.
36	Report of the Work of Koilpatti Agricultural Station for 1916-17. Price As. 3 or 3*d.*	Ditto ..	Ditto.
37	Report of the Work of Hagari Agricultural Station for 1916-17. Price As. 2 or 2*d.*	Ditto ..	Ditto.
38	Report of the Work of Coimbatore Agricultural Station for 1916-17. Price A. 1-6 or 2*d.*	Ditto ..	Ditto.
39	Report of the Work of Manganallur Agricultural Station for 1916-17. Price As. 3 or 3*d.*	Ditto ..	Ditto.
40	Report of the Work of Nandyal Agricultural Station for 1916-17. Price A. 1-6 or 2*d.*	Ditto ..	Ditto.
41	Report of the Work of Sirvel Agricultural Station for 1916-17. Price 1 anna or 1*d.*	Ditto ..	Ditto.
42	Green Manure Crops suitable for the Northern Circars and the Ceded Districts. Leaflet No. VI of 1917.	Ditto ..	Ditto.
43	Green Manure Crops suitable for Tamil Districts. Leaflet No. VII of 1917.	Ditto ..	Ditto.
44	*Sorghum* for fodder on the Black Soils of Bellary District. Leaflet No. VIII of 1917.	Ditto ..	Ditto.
45	The Coconut. Leaflet No. IX of 1917.	Ditto ..	Ditto.
46	Songs on Improved Methods of Paddy Cultivation. Leaflet No. X of 1917.	Ditto ..	Ditto.
47	Song on Preventive Methods to protect Mango Flowering. Leaflet No. XI of 1917.	Ditto ..	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		General Agriculture—contd.	
48	Hints to Ryots of the IV Circle on Green-Manuring. Leaflet No. XII of 1917.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
49	A Survey of the Madras Dairy Trade. Bulletin No. 73.	Allen Carruth, Deputy Director of Agriculture for Live Stock, Madras.	Ditto.
50	Report on the Working of the Department of Agriculture, Central Provinces and Berar, for 1916-17. Price R. 1 or 1*s.* 6*d.*	Issued by the Department of Agriculture, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
51	Season and Crop Report of the Central Provinces and Berar for 1916-17. Price As. 8 or 9*d.*	Ditto ..	Ditto.
52	Report on Agricultural Stations, Southern Circle, for 1916-17. Price R. 1.	Ditto ..	Ditto.
53	Report on Agricultural Stations, Northern Circle, for 1916-17. Price As. 8.	Ditto ..	Ditto.
54	Report on Agricultural Stations, Western Circle, for 1916-17. Price As. 8.	Ditto ..	Ditto.
55	Report on the Experimental Farm attached to the Agricultural College, Nagpur, for 1916-17. Price As. 8.	Ditto ..	Ditto.
56	Report on the Demonstration Work in the Southern Circle, for 1916-17. Price As. 8.	Ditto ..	Ditto.
57	Report on the Demonstration Work in the Northern Circle, for 1916-17. Price As. 8.	Ditto ...	Ditto.
58	Report on the Demonstration Work in the Western Circle, for 1916-17. Price As. 8.	Ditto ..	Ditto.
59	Report on the Agricultural College, Botanical and Chemical Research, and Maharajbagh Menagerie for 1916-17. Price As. 8.	Ditto ..	Ditto.
60	The *Agricultural and Co-operative Gazette* (Monthly) from August 1917 to January 1918. Price As. 2 per copy.	Ditto ..	Shalom Press, Nagpur.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
		General Agriculture—contd.	
61	Report on the Operations of the Department of Agriculture, Burma, for the year ending 30th June, 1917.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
62	Season and Crop Report of Burma for 1916-17. Price As. 10 or 11*d.*	Ditto ..	Ditto.
63	Cultivators' Leaflet No. 47 on *Pebyugale* (in English and Burmese).	Ditto ..	Ditto.
64	Annual Report of the Department of Agriculture, Assam, for the year ending 30th June, 1917. Price As. 8 or 9*d.*	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
65	Report on the Season and Crops of Assam, for 1916-17. Price As. 8 or 9*d.*	Ditto ..	Ditto.
66	Annual Report of the Jorhat Agricultural Experiment Station for the year ending 30th June, 1917.	Ditto ..	Ditto.
67	Annual Report of the Upper Shillong Agricultural Experiment Station for the year ending 30th June, 1917.	Ditto	Ditto.
68	Annual Report of the Kamrup Sugarcane Experiment Station, for the year ending 30th June, 1917.	Ditto ..	Ditto.
69	Annual Report of the Karimganj Agricultural Experiment Station for the year ending 30th June, 1917.	Ditto ..	Ditto.
70	Annual Report of the Fruit Experiment Station, Shillong, for the year ending 30th June, 1917.	Ditto ..	Ditto.
71	Annual Report of the Agricultural Experiments and Demonstrations in Assam for the year ending 30th June, 1917.	Ditto ..	Ditto.
72	Report on the Season and Crops of the North-West Frontier Province for 1916-17. Price R. 1 or 1*s.* 4*d.*	Issued by the Department of Agriculture, North-West Frontier Province.	Government Press, Peshawar.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
73	Annual Report of the Peshawar Agricultural Station at Tarnab, for the year ending 30th June, 1917.	Issued by the Department of Agriculture, North-West Frontier Province.	Government Press, Peshawar.
74	The Irrigation of Alluvial Soils, Bulletin No. 7 of 1917 of the Fruit Experiment Station, Quetta.	Albert Howard, C.I.E., M.A., Imperial Economic Botanist, Pusa; and Gabrielle L. C. Howard, M.A., Second Imperial Economic Botanist, Pusa (on deputation under the Baluchistan Government).	Baptist Mission Press, Calcutta.
75	The Sun-Drying of Vegetables. Bulletin No. 8 of 1917 of the Fruit Experiment Station, Quetta.	Ditto ..	Ditto.
76	Review of the Progress of Agriculture in States of Central India for 1916-17.	Bernard Coventry, C.I.E., Agricultural Adviser to States in Central India.	Ditto.
77	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual subscription R. 1.	Madras Agricultural Students' Union, Coimbatore.	Literary Sun Press, Coimbatore.
78	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
79	The *Journal of Dairying and Dairy-Farming in India* (Quarterly). Subscription Rs. 5 per annum (including membership).	Published by the Indian Committee of the Dairy Education Association, Quetta.	Messrs. Thacker, Spink & Co., Calcutta.
80	*Poona Agricultural College Magazine* (Quarterly). Annual subscription Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
	AGRICULTURAL CHEMISTRY.		
81	The Composition of some Indian Feeding Stuffs. Bulletin No. 70 of the Pusa Agricultural Research Institute. Price As. 10 or 1*s.*	Jatindra Nath Sen, M.A., F.C.S., Officiating Imperial Agricultural Chemist.	Government Printing, India, Calcutta.
	MYCOLOGY.		
82	Proceedings of the Mycological Conference held at Pusa on the 5th February 1917 and following days. Price As. 2 or 2*d.*	Imperial Mycologist, Agricultural Research Institute, Pusa.	Government Printing, India, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

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	Mycology—concld.		
83	*Orobanche* as a Parasite in Bihar. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. IX, No. 3. Price R. 1 or 1*s.* 6*d.*	F. J. F. Shaw, D.Sc. (Lond.), A.R.C.S., F.L.S., Second Imperial Mycologist.	Messrs. Thacker, Spink & Co., Calcutta.
	ENTOMOLOGY.		
84	The Indian Sugarcane Leafhopper (*Pyrilla aberrans*, Kirby). Memoirs of the Department of Agriculture in India, Entomological Series, Vol. V, No. 2. Price Rs. 2 or 3*s.*	C. S. Misra, B.A., First Assistant to the Imperial Entomologist.	Messrs. Thacker, Spink & Co., Calcutta.
85	Report on a Collection of Termites from India. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. V, No. 3. Price R. 1 or 1*s.* 6*d.*	Karin and Nils Holmgren, Högskolas Zootomiska Institut, Stockholm. Translated by T. Bainbrigge Fletcher, R.N., F.L.S., F.Z.S., Imperial Entomologist, Pusa.	Ditto.
86	On a Collection of Sphecoidea sent by the Agricultural Research Institute, Pusa, Bihar. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. V, No. 4. Price As. 12 or 1*s.*	Rowland E. Turner, F.Z.S., F.E.S.	Ditto.
87	Report of the Proceedings of the Second Entomological Meeting held at Pusa on the 5th—12th February 1917. Price Rs. 3 or 4*s.* 6*d.*	T. Bainbrigge Fletcher, R.N., F.L.S., F.Z.S., Imperial Entomologist.	Government Printing, India, Calcutta.
88	Second Report on the Experiments carried out at Pusa to improve the Mulberry Silk Industry, compiled under the direction of the Imperial Entomologist, Pusa. Bulletin No. 74 of the Pusa Agricultural Research Institute. Price As. 4 or 5*d.*	M. N. De, Sericultural Assistant, Pusa.	Ditto.
	VETERINARY.		
89	Annual Report of the Imperial Bacteriologist, Muktesar Laboratories, for the year ending 31st March 1917. Price As. 5 or 6*d.*	Issued by the Agricultural Adviser to the Government of India, Pusa.	Government Printing, India, Calcutta.

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SIR FRANK GEORGE SLY, K. C. S. I., I. C. S.,
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Original Articles.

THE TRUE SPHERE OF CENTRAL CO-OPERATIVE BANKS.

BY

R. B. EWBANK, I.C.S.,

Registrar of Co-operative Societies, Bombay Presidency.

During the last few years there has been a distinct tendency in several Indian provinces to make the District Central Bank the pivot of co-operative administration. The tendency is perhaps most marked in the Central Provinces, the United Provinces, and Bihar and Orissa, but it is also discernible in Bengal and the Punjab and has on more than one occasion tinged the views of the Government of India itself. The theory that the District Central Bank cannot stop at the mere finance of local societies but should and must go further and assume general supervision and control over their management has in its most advanced form been eloquently advocated by Mr. H. R. Crosthwaite, C.I.E., in his book "Co-operative Studies and the Central Provinces System." The success of his system both within and outside the Central Provinces, backed by the vigour of his argument, has already made a deep impression on public opinion, and it appears probable that, unless some note of warning is sounded, the bias towards uniformity which sooner or later infects all official activities will bring the system universally into force throughout India. While several provinces remain uncommitted to this line of development, it may be worth while to pause and consider whether in the long run it is likely to lead to the bes possible results.

About the primary functions of District Central Banks in India, there is no room for difference of opinion. They have been defined by the Committee on Co-operation as the balancing of the surplus funds of affiliated societies and the provision of necessary capital. It is evident that these Banks cannot discharge the second function properly without some agency for inspecting the working of borrowing societies and estimating the extent of the credit that may legitimately be granted to them. A Central Bank needs therefore a field staff to verify the material assets owned by borrowing societies and to look into their general management and trustworthiness. It must have the means of judging independently the real needs of societies, the value of the security which they offer, and the amount that can usefully and safely be advanced to them. Otherwise their loans may do more harm than good, and may turn out in the end to be irrecoverable. Up to this point all co-operative authorities are agreed.

But in several parts of India Central Banks have extended their functions and powers far beyond this modest point. For instance, in many places the Board of a Central Bank is expected to undertake all propagandist work and the organization of new societies within its own area. It is to this board and particularly to its paid staff that new societies have to look for instruction, training, and advice. Through the Provincial Federation, where such exists, Central Banks have a large voice in the control of the auditing staff and every Bank is required to deal effectively with all audit notes on affiliated societies. They have to issue orders for the remedying of faults and to see that they are carried into effect. They are expected not only to control rural credit and stimulate thrift but to serve as centres of agricultural improvement and to carry on wholesale purchase and sale business on behalf of their clients. At the meeting of the Board of Agriculture in 1916 resolutions were actually passed that "The Registrar and Director of Agriculture should arrange for such practical training in agriculture as may be necessary and possible for the staff of Central Banks," and that "a Government official, subordinate to the Deputy Director of Agriculture, should be attached to each Central Bank which is

sufficiently developed." In order thoroughly to cement and rivet the intimate union of Central Banks with their affiliated societies, the latter are required to deposit their reserve funds and their individual members to subscribe to shares in the former. In fact primary societies have been delivered over, bound hand and foot, into the custody of Central Banks and enjoy just so much liberty as the Board of Directors may choose to allow to them. The Central Bank is leviathan and the local societies are the mere barnacles on its back.

This state of affairs has sprung from a theory of the essential unity of the whole movement which has been very forcibly put by Mr. Crosthwaite. "It cannot be too thoroughly understood that the credit enjoyed by each unit depends entirely on the stability and business reputation of the system as a whole. The correct view of your organization is that of an army with its general (the Governor of the Federation), its staff (the Federation Congress), its corps commanders (the Directorates of the Central Bank), its regimental colonels (the Committees of the Unions of primary societies), and its company officers (the Panchayats of the primary societies). Without a plan of campaign, without discipline, and without a responsible and guiding head, an army would be nothing but a disorderly mob, futile as a fighting machine. Without a definite policy, without co-ordination of effort, and without a liberal allowance of unselfishness, our co-operative system would be futile as a machine for the promotion of the economic welfare of the province. It is therefore the task of every educated co-operator to teach and train the men for whom he is responsible, to instil into them the virtues upon which the movement is based (and in the absence of which it cannot exist), and to set his face resolutely against the blighting influence of the parochial spirit." The gospel of centralization could scarcely be preached in more unequivocal language.

It is perfectly true that the credit enjoyed by each individual society is to some extent derived from the general credit of the whole movement, and that the failure of a society reacts on the credit of the whole group to which it belongs. Societies owe it to their

neighbours to obey certain rules of discipline and to maintain a certain average standard of efficiency, and where they fail to realize this, their neighbours are entitled in the general interest to interfere and to exact obedience. But beyond this the military analogy ought not to be pressed. The credit of each individual society is at least as much due to the integrity of its particular committee, the punctuality of its members, and the strictness of its management, as to the general reputation of the whole co-operative system to which it belongs. In the case of first-rate individual societies this fact is obvious, and even if all the local societies of a province are taken together, it will be found that in several provinces more than half of their total working capital is derived from local sources by the local credit of the committee rather than from central financing institutions. The key of the credit of the movement is in fact found in the individual village society, and not in the Central Bank. Mr. H. W. Wolff, the wisest and most far-sighted critic who has yet treated of the co-operative movement in India, has recently hinted [1] that co-operative credit in India seems to him to be getting near the danger zone on account of its "organization from top to bottom, threatening over-centralization, and interlinking of liability." He has made this point clearer in a later article.[2] "Central Banks are at present approving themselves as exceedingly useful. But they inevitably shift the centre of gravity for each local district from the place where it should be and where there is direct power of observation and control to another place where minutiæ cannot be observed. It is the Central Bank which is becoming the seat of responsibility, the checker of applications, the granter of credit. The local member in the primary societies loses the full mastery over his own liabilities. It is only in the local bank, managing its own affairs, that true co-operative education can be given, which is the greatest benefit bestowed by co-operation and which is surely nowhere more needed than in India."

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[1] *Bengal Co-operative Journal*, vol. III, no. 4, p. 277.
[2] *Bombay Co-operative Quarterly*, vol. I, no. 4, p. 153.

No doubt local societies have their representatives on the Board of the Central Bank and have a large voice in its management. But that does not make control by a Central Bank the same thing as self-control under which every society is free to determine its own fate. The general credit of the system as a whole ought not to be made too much of a fetish. A few failures here and there will not appreciably affect it. If local societies are always kept in swaddling clothes and guarded from every natural accident and error with too grandmotherly a care, they will never learn to stand on their own legs. Mistakes are bracing. Provided that a guiding hand is ready to be stretched out when a society stumbles, it ought not to be protected too carefully against itself. The Act, rules, and by-laws form a sort of Manual of management, and the annual audit serves to show up all mistakes and infringements of the principles there laid down. In most cases the Local Union is at hand to warn and advise. If in addition to all this the Central Bank smothers a society with well-intentioned regulations and constant guidance, it saps its independence and in the long run may ruin it as a healthy economic organism. The true function of a Central Bank is simply to say " yes " or " no " to loan applications, and when it says " no " to explain why, in order that a society may know in what way its credit is defective. Owing to rural illiteracy, a Central Bank should perhaps go rather further in India and help societies which are incapable of helping themselves, to build up their credit and to earn the confidence of the financing institution. But they should not be permitted to usurp complete domination over the movement within their district. Their true sphere is finance and not administration and control. In the words of Mr. Wolff: " The Central Bank is, when all has been got ship-shape, to serve, not to be tutor to, the local banks. It is in fact designed to be a ' bank.' In Europe I prefer that it should be a joint-stock company. Its manager's proper business is that of bankers qualified to meet commercial bankers on their own ground and form a link between the co-operative and the banking world."

The main reason why so much power has been concentrated in some provinces in the Central Banks is no doubt the dearth

of educated men of enterprise and business ability outside the big towns. It was felt that the ryots were too feeble and ignorant to take full powers of management into their own hands for many years to come. The choice seemed therefore to lie between an immense increase in the official supervising staff and reliance on a committee of public-spirited non-official gentlemen controlling local societies through a bank at headquarters. The latter alternative was naturally preferred and in some banks very good work has been done. But experience has shown that this result is by no means universal. Mr. R. W. D. Willoughby, I.C.S., Registrar of Co-operative Societies, United Provinces, has in his last Administration Report criticized the system in language that is certainly not wanting in candour or vigour :—"The system to which we are committed in this province entrusts the finance, supervision, and indeed the whole fortunes of the movement to the District and Central Banks. These banks are administered by Boards of Directors who are predominately urban and professional. Such bodies are by their constitution ill-adapted to establish the intimate contact required for the fostering and training of such a delicate plant as the young village credit society or even for its control or finance when adult. The lawyer, banker, and other professional gentlemen can hardly be expected to find time constantly to visit villages, often distant, and to find out what his staff is doing there. They are inevitably dependent on their paid staff. Now no committee of townsfolk can lend money with advantage or safety to a multitude of individual rustics whom they have never seen and never met and whose credit they cannot gauge through a staff whom they cannot check or control. The attempt is apt to result in the mere substitution of the urban middle class for the village money-lender as the usurer without advantage to either lender or borrower. For with an uncontrolled staff the effective rate of interest really paid tends to be quite as high as the bania's.....Experience has continued to show that too many central societies regard their primaries rather as customers to be bled than as children to be fed." If this indictment be accepted as true, then it is clear that the system is already on the

verge of a break-down in one province and that there is a *primâ facie* case for examining the theory underlying it very carefully in the light of local conditions before encouraging its extension elsewhere.

A Central Bank is capable of undertaking banking business of every sort for its client societies, and of carrying out such inspection as is necessary for the assessment of credit, the punctual recovery of its loans, and other similar routine. In matters of finance centralization is not only unobjectionable but highly desirable ; and by its constitution the usual Indian Central Bank is well adapted to serve as the financial nerve-centre of its district. But when it widens its horizon and begins to stretch out tentacles towards the control of audit, training, organization, and propaganda, when in fact it centres all co-operative activity in itself and treats its ancillary societies as a company officer treats the soldiers under his command, then two great dangers begin to appear. Firstly, the Central Bank is trying to undertake more than it is fitted to perform, and is liable to overstrain its machinery and to break down, as has already perhaps happened in parts of the United Provinces. Secondly, the healthy growth of primary societies tends to be stifled by too much outside control. In many parts of India—certainly in large areas in Bombay and the Punjab—the ryots are substantial and independent men, perfectly competent to run their own societies once they have been shown how. A little adversity often stimulates them ; but frequent outside interference, not always quite disinterested, tends to enervate and dishearten them.

If the sphere of the Central Banks is restricted in the manner suggested, it will be asked what agency is available in their place to undertake the functions shorn off from them. The answer to this question entirely depends on local conditions. Except in matters of finance, where there are enormous advantages in a uniform system leading up in a pyramidal form from the local society through the local Central Bank to the apex Provincial Bank, uniformity as such ought to be shunned. The co-operative movement is a growing organism still half-developed. If it is cramped into a stereotyped frame, atrophy is bound to set in. Experiments should still be freely encouraged. The function of training and supervision so far

from being centralized like finance should be decentralized downwards. In Bombay Presidency it is being undertaken by small clusters of societies grouped in guaranteeing Unions on the Burma model, and in places where there are no Unions local co-operators and chairmen of first-rate societies are appointed as Honorary Organizers and Assistant Honorary Organizers and discharge these duties very zealously as a labour of love. General propagandism and the education of the public is being entrusted to a Central Co-operative Institute which is now under formation. When the time comes for societies to take over the duty of primary audit, it is intended to entrust it to federations of Unions, separately organized for each linguistic area. The Central Banks, under the enlightened guidance of the Bombay Central Co-operative Bank, have never sought to exceed the functions assigned to them by the Committee on Co-operation. Whatever the defects of this system may be, it has the merit of having left the primary society master in its own house, and of having made not the Central Bank but the local Union of primary societies the axis around which co-operative administration revolves. In other provinces other types of organization will no doubt be found more suitable. But the object of this paper will have been served if co-operators will think twice before acquiescing in any extension of the powers and influence of a Central Bank, which may convert it from the servant to the master of the co-operative societies within its area.

INDIAN COTTON COMMITTEE.

Standing: Mr. H. F. Ashton (Punjab Irrigation Department); Mr. G. S. Henderson, I. A. S.; Mr F. Noyce, I. C. S., (Secretary); Mr. W. Roberts, I. A. S.
Sitting: Mr. N. N. Wadia, C. I. E.; Mr. J. Mackenna, C. I. E., I. C. S., (President); Mr. F. Hodgkinson.

PLATE XXII.

THE EARLY HISTORY OF COTTON IN BOMBAY.*

BY

J. MACKENNA, C.I.E., I.C.S.,

Agricultural Adviser to the Government of India.

In December last I learned with great interest that a Students' Cotton Association had been formed in this college, the object of which was to study questions relating to cotton cultivation, manufacture and trade. Busy as I am, I had little hesitation in accepting the invitation to become its first President, for the formation of such an Association seemed to me a most hopeful sign of the times and to hold out great promise of future development. We are frequently told that one of the reasons why the development of Indian industry has been such a slow process has been the absence of *entrepreneurs* looking to the direction of organized industry as their natural source of wealth. To students of a College of Economics it is hardly necessary to explain the functions of an *entrepreneur* and I need only say that he is an essential link between capital and labour. Capital there is in India, if not in abundance, at any rate in large quantities, but it is often shy and difficult to secure. Labour there is, but it wants organization. Mr. Moreland recently pointed out, in an article in the *Quarterly Review*, which I expect many of you have read, the difficulties in regard to the supply of capital and the organization of labour in India. He added that to face these difficulties with a fair prospect of success required a combination of enterprise and experience which was unfortunately rare in India, and that this scarcity of men of the right sort was

* A lecture delivered to the Students' Cotton Association of the Sydenham College of Commerce, Bombay, on 28th January 1918.

probably the greatest single obstacle to the industrial development of this country. It appears to me that the existence of such a college as the Sydenham College of Commerce and Economics should have a great effect in removing this obstacle, and the formation of such an Association as that which I am addressing shews that there are many of you who are fully alive to the opportunities which are offered you here. The greatest need of Indian industry is men who are capable of shouldering responsibility: in the towns, competent managers of departments and foremen; in the country, competent men to place in charge of buying agencies and so on. The enterprise which has started this Association will, it is to be hoped and expected, not be entirely expanded within the walls of this college but will lead its members far when they go out into the world and remove one of the standing reproaches to Indian industry. A very successful commercial man of my acquaintance at home once told me that a piece of advice he was fond of giving to a young man starting work under him was that he should make it his aim always to qualify himself for the appointment of the man immediately above him. It struck me as a very sound piece of advice and I pass it on to you. Possibly it may assist in the production of a budding Tata or Wadia from among your ranks.

This is, as far as I know, the first Association of students which has been formed in India to study the cultivation and manufacture of, and the trade in, one particular product. Doubtless we shall shortly hear that Calcutta, not to be outdone by Bombay, has formed a Students' Jute Association, for jute is the only Indian industry at all comparable with cotton. If we do—well, wholesome rivalry is to be welcomed and a debate between the students of the two Associations as to the merits and importance of their respective fibres would, I am sure, attract a large and appreciative audience!

It was only natural that the first Students' Cotton Association should be formed in Bombay, for Bombay *is* the Indian cotton trade centre. In every respect, whether it be as regards cultivation, manufacture or trade, this Presidency is so easily ahead of all other provinces that it is a case of Bombay first and the rest nowhere. Figures are usually regarded as dull but they have their advantages

in proving a point, and I propose to give you a few for that purpose. I am not particularly fond of them myself and I have not therefore subjected myself to the labour of working out averages, but as the proportions are much the same whatever year you take, we will take the last for which statistics are available. In 1916-17, the area under cotton in the Bombay Presidency, excluding Sind, was 6,394,000 acres out of a total of 21,210,000 acres for the whole of India, that is, it was just under one-third. The only other province with any area under cotton at all comparable with this was the Central Provinces with 4,401,000 acres under cotton and that province forms part of the hinterland of this. The out-turn of cotton from Bombay was 1,519,000 bales out of a total of 4,557,000 bales. Passing next to manufacture, we find that the preponderance is even more marked. Of the 267 spinning and weaving mills in India in 1915-16, 175 were in this Presidency and 86 were in Bombay itself. Of the $6\frac{1}{2}$ million spindles, over $4\frac{1}{2}$ millions were in this Presidency and nearly 3 millions in Bombay itself. Bombay City had almost half the 108,000 looms in India and the Presidency over three-quarters of them. Of the 292,160 men, women, and children employed in the cotton mills in India, 189,630 were employed in this Presidency. These figures were, of course, reflected in the output. Of about $722\frac{1}{2}$ million pounds of yarn produced in 1915-16, nearly 510 million pounds were produced in the Bombay Presidency. Of $352\frac{1}{4}$ million pounds of woven goods, about $287\frac{1}{2}$ million pounds were produced in Bombay. There is, however, one respect in which Madras is ahead of you. With a very much smaller number of mills, it produces very nearly as much yarn of higher counts *i.e.*, counts above 40's, as the whole of this Presidency and considerably more than Bombay City. Having examined the figures of cultivation and manufacture, let us turn to those of trade. Of exports of nearly 9 million cwt. of raw cotton in 1915-16 valued at about £$16\frac{1}{2}$ millions, rather over 7 million cwt. valued at nearly £$13\frac{1}{2}$ millions went from Bombay. Of exports of about $160\frac{1}{4}$ million pounds of cotton twist and yarn valued at £4,600,000, no less than $151\frac{3}{4}$ million pounds valued at £4,378,000 were exported from Bombay. Of exports

of cotton piece-goods, of nearly 118½ million yards valued at £1,645,000, 84,140,000 yards valued at about £896,000 were exported from Bombay. Nearly all the handkerchiefs and shawls exported from India, in value about £100,000, went from Madras, but almost all the hosiery and sewing threads were supplied by Bombay. In the import trade, Bombay is not so predominant and Calcutta had a big lead in the matter of imports of piece-goods. This one would naturally expect, for coals are not usually sent to Newcastle, and this Presidency is obviously more self-reliant in regard to piece-goods than any other part of India. An import of piece-goods to the value of nearly £5½ millions is by no means negligible. The figures I have given you show, I think, gentlemen, your wisdom in starting an Association for the study of cotton cultivation, manufacture and trade and also what a vast field of enquiry lies before you.

I will now pass on to the main subject of my address. You will, perhaps, wonder why I have selected the "Early History of Cotton in Bombay" to talk to you about this evening. You may have thought that there were various more up-to-date aspects of the problems connected with cotton about which I could have spoken. There is, for instance, the agricultural aspect. We might have considered why the yield of cotton per acre in this country is so low compared with that of Egypt or America. I might have given you a description of the botanical work which has been done on cotton though that would have been a subject more suitable for a President with more scientific knowledge than I can claim. Of the processes of spinning and weaving, you can get sufficient ocular knowledge in this city. Then there are the eternal problems of mixing and adulteration of which so much has been heard recently. But a little reflection will shew you that I could not have addressed you on any of these topics without saying more than would have been advisable at this stage in regard to the views of the Committee of which I have the honour also to be President. That is the reason why I turned to the "Early History of Cotton" in this Presidency as a non-contentious subject, but I hope you will agree with me at the end of evening that a study of it has not been without its uses.

In a book on which I have largely drawn for my material, though I have also gone to most of the original sources from which it was compiled, "Cotton in the Bombay Presidency" by Walter R. Cassels published in 1862, figures are given for the import of Indian yarn into England from as far back as 1703. These were obtained from the records of the East India Company. The total imports in 1703 amounted to 114,100 pounds. Prices do not appear in the list until 1706 when they were 2*s*. 2¾*d*. per lb. In 1801, over 56,000,000 pounds of "cotton wool," presumably ginned cotton, were imported into England, of which just under 4,100,000 pounds were from India. In 1710, the imports had been only 710,000 pounds. It was the genius of Hargreaves, Arkwright and Watt that had brought about this tremendous increase in the demand for cotton. It is very interesting, though anything but cheering, to remember that the imports of Indian cotton had attained some importance long before any American cotton reached England. The first shipment of American cotton was made in 1747 from Charleston and consisted only of seven bales. In 1784, about 14 bales were shipped to England but were seized in Liverpool as contraband. So little was known about the capacity of the United States to produce cotton that it was believed that it could not possibly have been grown there. It was first shipped in any quantity in 1791 when 189,316 lb. were exported, and the exports have gone on increasing more or less steadily ever since. The extraordinary development of the export of American cotton was due more than anything else to the invention of the Whitney sawgin which holds the same place in regard to it as Arkwright's spinning frame does to the development of the cotton industry of Great Britain. The gin enabled one man to clean more cotton in a day than he had previously been able to get through in a month. The invention of the gin was received with very different feelings from those with which the replacement of hand labour by machinery was usually regarded in those days. A crowd, whose industry had been restrained by want of means to separate the lint from the seed with sufficient rapidity, broke into Whitney's workshop and carried off his machine before it was complete or he had been able to secure a

patent for it. The year after it was completed, the export of cotton from the United States increased nearly 40-fold and by 1805 it had increased about 240-fold.

The constantly increasing demand for cotton excited the interest of the East India Company which began to wonder whether it could not obtain a larger share of a lucrative trade. In 1788, which is one of the landmarks in the history of Indian cotton, the Court of Directors called the earnest attention of the Governor-General to the necessity of generally encouraging and improving the cultivation of cotton in India. They requested him to take steps, in conjunction with the Government of Bombay, to send them at once half a million pounds of the best Broach and Surat cotton and the same quantity every year. In 1790, the Government of Bombay estimated the total production for the Presidency at 33,712,000 lb., of which 26,656,000 lb. were exported. The best quality, they said, was produced in Jambooser, Ahmood, and throughout the Pergunna of Broach. At that time the Company received the cotton loose and packed it themselves. This enhanced the price four or five rupees a *khandi* but they calculated that the extra price was more than made up for by the prevention of fraud in packing and the avoidance of sandy or leafy parcels. In order still further to encourage the trade, the Court of Directors, at the end of 1790, authorized ships carrying convicts to Botany Bay to go to Bombay and to carry home cotton on private account "under the inspection and direction of the Company's servants at that settlement, provided such cottons were sold at the Company's sale, subject to the usual expenses." 422,207 lb. were sent to London as a result of these steps but the highest price fetched was $10\frac{1}{2}d.$ a pound which was not considered sufficient. A quantity of Surat cotton smuggled from Ostend did not in the phraseology of the day "turn to a more productive account." The Court of Directors thereupon expressed the opinion that "it is evident, therefore, notwithstanding the flattering allurements held out by British manufacturers, that the article will by no means answer." For the next few years, very little Indian cotton was imported into England but in 1799, encouraged by an improvement in prices, the

Court instructed the Bombay Government to fill up any spare tonnage with cotton. Prices, however, again went down and the permission to load cotton was rescinded unless other freight failed to be forthcoming in which case the orders were that empty space should be used for cotton rather than that these boats should be sent away dead-freighted.

In 1810, the Company purchased a quantity of cotton for export to China, whereupon two Bombay firms, Messrs. Forbes & Co., a firm which is as vigorous now as it was a century ago, and Messrs. Favatt & Co., protested that the Government purchases had raised the price of cotton to Rs. 175 per *khandi* on the Bombay green, a price which they considered ruinous. They begged Government to withdraw its competition for a season offering to form a secret convention to supply at its actual cost the quantity of cotton required for the China trade during the year. The proposal was warmly supported by two members of the Bombay Council, Messrs. Rickards and Lechmere, but the Court of Directors stoutly denied that they monopolised the market or that they had procured cotton below its proper value "which it was not in the interests of the Company to do." They expressed the opinion that "a more extraordinary proposal did not stand upon their records than this" which they considered "a secret combination between buyers to narrow competition." Messrs. Rickards and Lechmere were accordingly removed from the Council of Bombay. Let us hope that a better fate awaits the members of the Indian Cotton Committee!

During these years, the fortunes of Indian cotton varied with the exports of American cotton, as they have done in much more recent times. In 1809, in anticipation of deficient supplies from America, the Court authorized all private ships to bring more cotton from India to London and, in consequence, about 30 million pounds were shipped to England. Only $1\frac{1}{4}$ million pounds of it were used by British manufacturers and $3\frac{1}{4}$ million pounds were exported to the Continent. Even at that early period, therefore, the greater part of the Indian exports of cotton to Europe went to the Continent, as they do to-day. The balance of $25\frac{1}{2}$ million pounds remained unsold in the Company's warehouses, and the Court complained

despondently of the adverse disposition manifested by British merchants in regard to it and, in the following year, that "it remained a ruinous and unproductive burthen both upon the Company and the private importers." They ordered that no cotton should be shipped to England on their account in 1812-13.

In consequence of these unfortunate experiences, the Court of Directors seem to have decided that their energies in regard to Indian cotton would be better directed towards an improvement in its staple. Some experiments with Bourbon cotton had been made in the Bombay Presidency from 1797 when Dr. Anderson was employed in distributing cotton seed from Mauritius and Malta throughout the Peninsula. A fresh supply was secured from Mauritius in 1812 and distributed to the Collectors of Broach and Surat. At that time, Bourbon plants were flourishing wild in the hedgerows of the Island of Salsette. I wonder how much cotton—wild or cultivated—there is to be found on Salsette nowadays. The first experiment on a large scale was made at Kaira in 1815 by an Assistant Surgeon named Gilders but "the slow growing perennial Bourbon attaining full vigour only in eighteen months persisted in the dry soil." A bale of cotton was, however, obtained from the experiment and consigned to London where it realized 1*s.* 5*d.* a pound or 2*d.* a pound more than the best Surat at the time. The next year, Mr. Gilders made a further experiment in the "Eastern Zillah between Subermuthy and Myhee," and obtained 44½ maunds of lint from 27 bighas of land. The cotton was valued at 2/3*d.* per pound in Bombay but only fetched 1/3*d.* in England against 5¾*d.* to 1/2¼*d.* for Surats. The expense of cultivating it was so great that there was a loss of 28 per cent. on the transaction. However, the Bombay Government considered the results sufficiently encouraging to justify their authorizing the Collector of the Eastern Zillah to offer a prize of Rs. 200 to the person who produced the greatest quantity of cotton of approved quality by a given period in the years 1819-20 from a given quantity of ground, with smaller prizes of Rs. 150, 100, and 50. These pecuniary inducements, however, met with no success.

Beyond the importation of two metal gins from Charleston in 1816, which were tried and reported to be unsuitable, nothing further seems to have happened till 1828. By that time the dependence of the British manufacturer on the American crop had become so marked that the desirability of finding a second if not an alternative source of supply could not be overlooked. Lord Ellenborough, the Chairman of the Indian Board, therefore suggested to the Court of Directors in 1828 "the expediency of attempting, on a small scale, the cultivation of all the finer sorts of foreign cotton in different and distant parts of India, under every different circumstances of soil and climate, and of transmitting to England, cleaned in the American manner, samples of the cotton so raised for comparison with the cottons of other countries." The Court of Directors, therefore, resolved to establish an experimental plantation at the cost of the State and directed the Bombay Government to select about 200 acres for the purpose to be placed under competent superintendence. They also directed that experiments on a small scale with the fine sorts of exotic cotton should be made in various parts of the Presidency, particularly in districts bordering on the sea coast. As a practical means of encouraging the cultivation of better cotton, they gave an order for 500 bales of the growing crop of Broach or Surat cotton, "to be gathered and prepared with the greatest attention." They also sent out a good supply of fresh Georgian Upland and New Orleans seed as well as two Whitney's sawgins. Acting on these instructions, the Bombay Government established the two first experimental farms in India. One in Broach was placed under the superintendence of Mr. Finney whilst the experiments in the Deccan, Khandesh, and Dharwar were placed in charge of Dr. Lush. Mr. Finney's only qualifications seem to have been that he had had experience on an indigo plantation in Bengal; Dr. Lush had, at any rate, some botanical training as he had been superintendent of the Botanical Gardens at Dapoorie. Against the Court's order for 500 bales, only 300 bales of suitable quality were secured. Part of this was ginned by the Southern Mahratta foot-roller gin, part by the *churka*, and part by the sawgin. The staple of the latter was reported to have been cut to pieces in ginning

and it was valued at about $\frac{1}{2}d.$ a pound less than that ginned by the *churka* and from $\frac{3}{4}d.$ to a penny a pound less than that ginned by the foot-roller gin. Mr. Finney died shortly after his appointment and was succeeded by a Mr. Martin who opened a farm of 3,000 bighas of land at Danda which produced about 74 bales of cotton in 1832, of which 18 bales were shipped to London where the injury done to the staple by the sawgin was again the subject of unfavourable comment. In 1831, the American cotton seed "failed from an insect which deposits its eggs in the pod before it has arrived at maturity, producing a worm which destroys the cotton," the first record, I believe, in the history of Indian cotton of the appearance of the bollworm. Egyptian, Pernambuco and Bourbon seed were also tried at Danda. It is unnecessary to give the details of the experiments year by year. It is sufficient to say that when they were finally abandoned in 1836, the report on them was that "with the exception of the Pernambuco, the foreign seed generally failed or yielded produce scarcely superior as a merchantable article to the indigenous Broach or Surat cottons. The produce of the seed raised from the original foreign seeds was also marked by a gradual deterioration in quality in the growth of each successive year." Dr. Lush's experiments in the Southern Mahratta Country met with no better success. This point is specially worthy of mention, for I have frequently seen the introduction of Dharwar American cotton into this country placed to the credit of this gentleman. He started a farm at Seegee Hullee in the Dharwar District but it did not prosper. He reported that the soil appeared best adapted to the culture of the white-seeded perennial, the Pernambuco and the Egyptian cotton, which last promised to succeed far better than the others. The entire crop available for shipment to England in 1831 only amounted to four bales, two of white-seeded perennial, one of American Upland, and one of New Orleans, and the value placed on them was from $7\frac{1}{2}d.$ to $8\frac{1}{2}d.$ per pound for "Candlewicks and jewellers' purposes." In 1835, undaunted by his failures, or as Mr. Cassels somewhat caustically observes, by his successes which were even more expensive than the failures, Dr. Lush proposed in 1835 to add about 1,000 acres to his Suggee Hullee

farm. The Bombay Government, however, declined to agree. Writing at the end of this year, Dr. Lush reported that, with the exception of the naturalized Pernambuco and a late trial with the Egyptian seed, all foreign cottons of long staple had become short. He added that the American sawgin had been a failure. In 1836, the Government of Bombay decided on the abolition of the experimental farms. Sir Robert Grant, the Governor, recorded his opinion that the experiment had been tried sufficiently and had failed. For the next few years Government contented itself with unsuccessful efforts to improve the *churka*. Nothing that had been done had so far made any impression on the ryots and Sir John Rivett Carnac, the Governor of Bombay, pointed out that no encouragement which had been extended could avail with them against the one circumstance that dirty cotton gave a better return than clean, an opinion which has been repeated at intervals ever since.

In 1838, the state of affairs at home once again caused attention to be turned to India. Urgent memorials were submitted to the Court of Directors by the Chambers of Commerce of Manchester and Glasgow and the East India Associations of Liverpool and Glasgow and were forwarded to the Governor-General with a despatch in which the members of the Court signed themselves "Your affectionate friends," a form of signature which it is to be regretted has fallen out of use in official correspondence. It is certainly somewhat less stilted than "We have the honour to be, Sir, Your most obedient servants."

The next step, and a very bold one, determined on by the Court of Directors, was the engagement of American planters for the purpose of instructing the cultivators of India in the cultivation and proper method of cleaning cotton. Captain Bayles of the Madras Army was deputed to engage experienced and competent men. India was then, I need hardly say, a much more unknown country in the United States than it is now, and, as was to be expected, he had great difficulty in securing suitable men. He finally recruited twelve and got them safely to India in September 1840. Three of them were allotted to Bombay, where they started work at Broach. In 1841-42, about 350 bighas of land were sown with New Orleans

seed which "vegetated in a most luxuriant manner, growing strong and healthy, showing abundance of blossoms, but no sooner had the first rains ceased than it became blighted and stunted, from which state it had never afterwards recovered." The planters expressed the opinion that the American cotton plant could not be cultivated so as to yield a profitable return or equal the quality and quantity of the same plant in America. They thought, however, that the quality of the indigenous cotton might be improved. So little hope, however, had they of ultimate success and so discontented were they with the terms of their engagement that they resigned their appointments and returned to America. The abandonment of the farm was at first contemplated, but, in consequence of a memorial from the Bombay Chamber of Commerce, it was decided to continue the experiments, and another of the planters, a Mr. Hawley, was transferred from Madras to Bombay. His efforts met with no better success than those of his predecessors. In 1842-43, 475 pounds or $11\frac{1}{4}$ pounds per acre was all the cotton gathered from 40 acres sown with New Orleans, Sea Island and Bourbon seed. A solitary bale of Bourbon cotton was produced in 1844. The total expenditure in Broach up to the end of the season 1843-44 was Rs. 1,21,462. The known and estimated value of the cotton grown amounted to Rs. 55,000 only, leaving a loss of Rs. 67,000 during four years, exclusive of charges for machinery from England. In 1847, the experiments were transferred to the charge of Mr. Mercer, another of the American planters, whose efforts in Dharwar will be mentioned presently. He went on leave shortly afterwards and in 1849 the Bombay Government resolved to abandon the experiments as useless. Their only result had been "to show that some kinds of exotics such as New Orleans and Bourbon yielded a small crop occasionally when cultivated as garden plants with great care and expense and that by double the care and attention and more than double the expense of the native cultivation, a larger yield and better and cleaner quality might be obtained from the indigenous cotton than the ryots can produce, but not sufficiently so to repay the additional outlay: and, finally, that the native cotton when cleaned by the American sawgin was generally injured in its staple."

The history of the failure to establish exotics in Broach is typical of that of the experiments in most other districts, and I will not weary you with details. Khandesh had the benefit of the services of two of the American planters, Mr. Blount who was transferred there from Gorakhpur in the United Provinces in 1845 and Mr. Simpson transferred from Madras shortly afterwards. The latter took over sole charge in 1846, when Mr. Blount was moved to Dharwar. The history of the twelve planters would form an interesting subject for a separate study if one had time to work it out. Mr. Simpson abandoned the idea of an experimental farm altogether and entered into contracts with ryots for the cultivation of New Orleans cotton at the rate of Rs. 5 per bigha, with remission of land tax. About this period, Mr. Elphinstone became Collector of Khandesh and took a lively interest in the extension of the cultivation of American cotton. Largely as a result of his exertions, the area under it went up to 13,619 bighas in 1851-52, but the crop was a partial failure owing to the cessation of the rains in September, and Mr. Elphinstone was compelled to admit that the experiments had not been successful. In 1854, the office of Superintendent of Experiments in Khandesh was abolished. In Surat, Ahmedabad, Kaira, Ahmednagar, Satara, Sholapur, Thana, and Ratnagiri in which district Mr. Elphinstone again made extensive trials, there is the same melancholy record of experiments undertaken and abandoned. In Belgaum, fortunes fluctuated to a greater extent, but I will not go into the matter as time is getting on and I wish to pass to the one bright spot, Dharwar. After Dr. Lush's failures, which, as I have said, later generations, with a perverted historical sense, have magnified into success, nothing was done until 1842, when Mr. A. N. Shaw, the Collector, to whom more than anyone else belongs the credit which attaches to the introduction of Dharwar American cotton, began to take an active interest in the cultivation of exotics and grew some New Orleans seed in the Hubli Taluka. Mr. Mercer, who has already been mentioned, and who had been transferred from the United Provinces to Bombay, reported most favourably on the results, though he said that the staple was not equal to that of the same description of cotton grown in America.

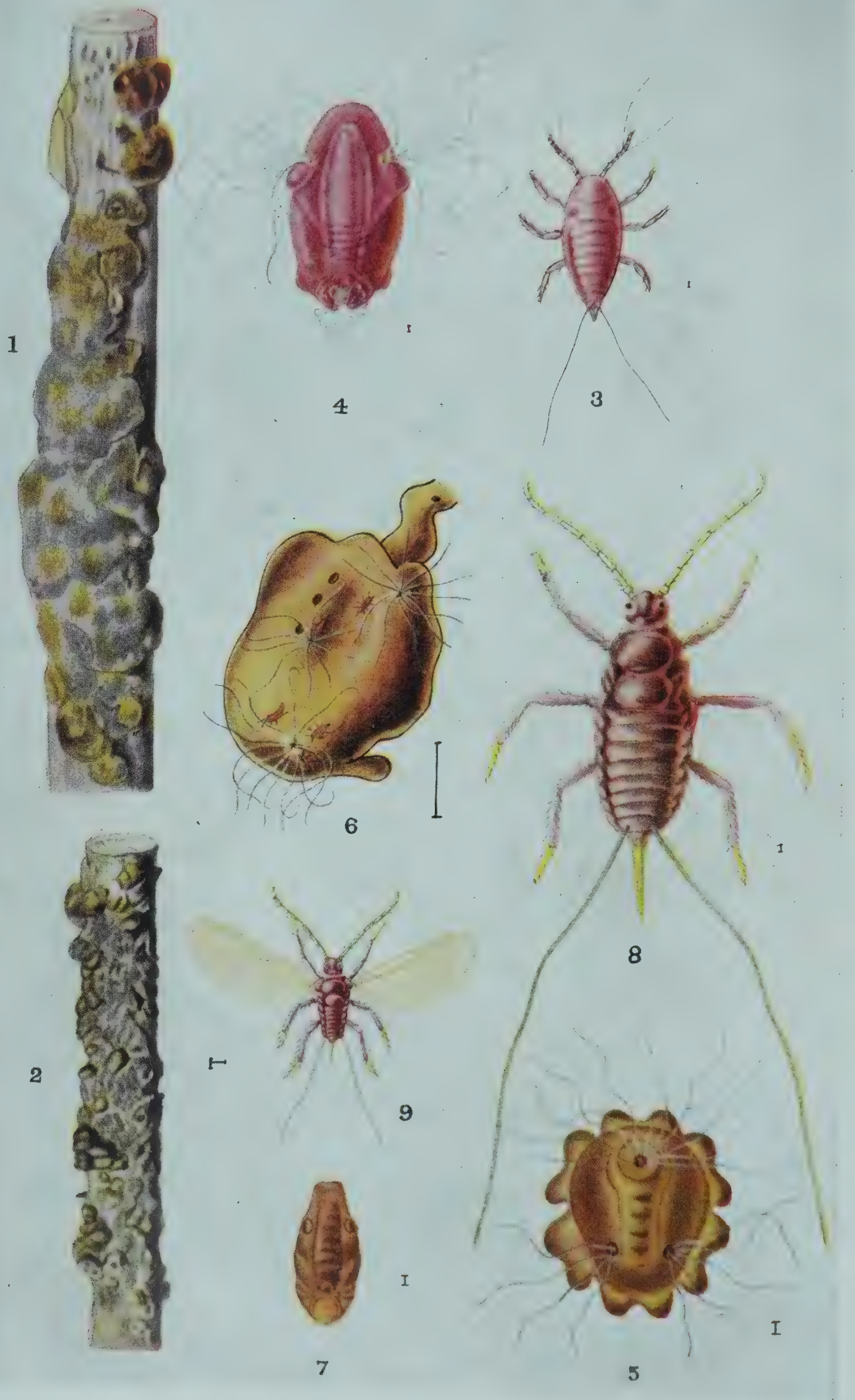
In 1843, Mr. Mercer was appointed to superintend a series of experiments in the Dharwar District and was given the assistance of Mr. Hawley, another of the planters, and of a Mr. Channing. Land was selected in Koosighul in the Hubli Taluka, and seed was supplied by Dr. Wight from Coimbatore. In June 1843, Mr. Shaw issued a circular setting forth the advantages of the exotic cotton, giving instructions as to how it should be cultivated, and guaranteeing the cultivators against loss from bad seed. Five hundred and forty-five acres were sown with exotics that year, including 183 acres of the experimental farm. Of the latter, 80 acres were planted with New Orleans and 63 with Broach. These two varieties gave the largest yields. Five sawgins were imported from Broach and Coimbatore and the whole of the farm produce was ginned by them. It was decided to confine further experiments to Broach and New Orleans. In 1844-45, the cultivation of exotics was extended to 3,749 acres. A second small experimental farm was opened at Garag and placed under the care of Mr. Hawley. Mr. Shaw left the district at the beginning of that year. At the suggestion of the Court of Directors, the Bombay Government empowered his successor, Mr. Goldsmid, to purchase from 500 to 1,000 bales of cleanly picked and carefully ginned New Orleans cotton at a price "so much above that of cotton in the state in which it is usually brought into the market as the differences of real value will justify." The Bombay Chamber of Commerce reported on the New Orleans cotton as short and weak in staple, and thought it better adapted for the China market than for export to England. The Government, however, shipped the whole produce of the ryots as well as that of the farm, about 280 bales in all, to Liverpool, where it fetched $3\frac{3}{4}d.$ a lb. against $4d.$ to $6d.$ for Surats. At the beginning of 1845 it was decided to abolish the two experimental farms, "as being cultivated precisely on the native system, they did not serve the purpose of model farms." The only deviation which had been introduced was that cotton was planted for two years running on the same land with indifferent success and it was considered that this prevented the planters from superintending the harvesting operations of the ryots. The planters

were allowed to contract with ryots for the cultivation of New Orleans cotton under their own direction. They accordingly contracted for about 836 acres at the rate of two rupees an acre in excess of the rent, the picking of the crops to be at their expense and the produce to belong to Government. The details of this arrangement are, it will be noticed, not quite as clear as they might be. In 1845-46, the cultivation of New Orleans increased to 11,176 acres. The contract system was abandoned after this one season as there had been such a rapid increase in the land under New Orleans, and Government contented itself with a virtual pledge to purchase the crop, if necessary. The total quantity purchased by Government amounted to 563 *khandis*. A little of it was sold in Bombay in conjunction with cotton from the other experimental farms in Belgaum and Khandesh at an average price of Rs. 29-8 per *khandi* above that of Surats, Kumptas, and Oomrawattees. In 1846, the cultivation increased to 22,331 acres and the produce was, in great part, bought by native merchants on their own account at Rs. 15 per *khandi* above the price of indigenous cotton. That year Mr. Hawley resigned and Mr. Mercer left Dharwar for Khandesh, being replaced by Mr. Blount. The number of sawgins in the district had by this time increased to 29. In 1848-49, the area under American cotton fell to 3,351 acres. Government ordered an enquiry which showed that the fall was largely due to the fact that the cultivators had been compelled, or regarded themselves as compelled, to cultivate New Orleans and to the difficulties in getting their produce ginned. More gins were provided in consequence, and the Collector was authorized to purchase the whole of the crop. As a result of these measures, the cultivation again increased to 15,573 acres in 1849-50, to 31,688 in 1850-51, and went on growing until it reached 178,682 acres in 1861-62. About 1858, the reputation of Dharwar American cotton fell, this being due according to Dr. Forbes—a well-known name in the history of Bombay cotton—to the adulteration and mixture of New Orleans with indigenous cotton. The difference in price between Kumpta and Dharwar, which in 1850-51 had been from 1*d.* to 1⅝*d.*, had fallen in 1859 to a farthing. Dr. Forbes took steps to prevent the careless sowing of mixed American and

indigenous seed and to secure that the sawgins should be kept in good order. This resulted in a marked improvement in the quality of the cotton.

We will stop our lengthy survey of the early history of Bombay cotton at this point. With the American Civil War and the consequent appointment of Cotton Commissioners for Bombay and the Central Provinces, and subsequently one for Cotton and Commerce with the Government of India, a new era in the history of Indian cotton begins. One fact I should have mentioned was the Cotton Adulteration Regulation of 1829, which provided penalties for the fraudulent mixing of good and bad descriptions of cotton, for the adulteration of cotton with stones, earth or salt water and for exposing it at night to heavy dews. This Act did not extend to Bombay itself but, on the representation of the Bombay Chamber of Commerce, a very similar Act was passed in 1851 for the islands of Bombay and Colaba. Neither of the Acts proved very effective in practice in stopping damping and adulteration, mainly because no machinery was provided for enforcing their provisions.

As I said at the outset, you may have wondered why I have inflicted all this history upon you. But I think you will now agree that it has been useful in showing you that almost every problem which the Indian Cotton Committee is attempting to solve dates from the early years of the British connection with India. You will now be able to realize some of the difficulties which confront the Committee. You will see that from the outset England turned to India as a source of supply of cotton but never succeeded in getting what she wanted. Whether the Committee will succeed in solving the question whether better cotton can be grown in India remains to be seen. In conclusion, it will, I would suggest, be a useful task for you to discuss amongst yourselves at future meetings of the Association, why it was that the experiments with exotics in the various parts of the Presidency proved a failure, except in the case of Dharwar, why it is that it is so difficult to prevent damping and adulteration, and the various other questions which arise out of the early history of cotton in Bombay.



TACHARDIA LACCA

EXPLANATION OF PLATE XXIII.

Fig. 1. Healthy insects on stick.
„ 2. Unhealthy „ „ „
„ 3. Young lac insect. × 40.
„ 4. A female 4 weeks old. × 35.
„ 5. „ 13 „ × 15.
„ 6. Young lac insects emerging from a female cell. × 4.
„ 7. Male cell, 13 weeks old. × 12.
„ 8. Wingless male. × 12.
„ 9. Winged male. × 40.

THE PRESENT CONDITION OF LAC CULTIVATION IN THE PLAINS OF INDIA.

BY

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At a time when every mind is busy with schemes of development, when every effort alike of experts and industrialists is employed on doing something to improve the general and economic condition of the poorer classes, no excuse should be needed for calling attention to an industry which is as old established as it is important. From time immemorial it has formed the means of livelihood of thousands, if not millions, of the poorer classes of India, especially the aborigines inhabiting the outskirts of forests and such other areas where the hosts of the lac insect abound. That lac is a resinous secretion produced by an insect which sucks the juice of plants and transforms it into resin which surrounds it completely may not be known to some readers of this Journal. The secretion comes out of the epidermis of the insect which on exposure hardens into a deep red or orange-coloured substance, semi-transparent and hard, breaking with crystalline fracture. The insect belongs to a group commonly known as scale insects. It is found growing spontaneously on a large number of trees [*Bulletin No. 28, Pusa Agri. Res. Inst.*, (Revised edition), page 2]. At the time of emergence the young insect is one-twenty-fifth of an inch long, deep red in colour, with three pairs of legs, a pair of feelers, a small bent tube and a pair of thin hairs at the end of the body (Plate XXIII, fig. 3). It is very sluggish in its movements and wanders about until it comes upon a suitable spot to fix itself. When once fixed it cannot be removed. After

fixation it thrusts its beak into the tissues of the stem and begins sucking the juice. The sap thus taken into the body is greatly transformed and is given out uniformly through pores all over the body in the form of resin, which after a few days encases it completely. If the young insect is a female it remains fixed once for all. If a male it emerges twice a year either as a winged or wingless little creature (Plate XXIII, figs. 8, 9), which after fertilizing the female dies. After fertilization the female develops fast. It takes in more sap, consequently exudes more resin and swells up (Plate XXIII, fig. 6). The lac-bearing branches are then cut off and placed on trees having a sufficient number of succulent branches. When the young insects have swarmed out, the old lac-bearing branches are removed, the resinous encrustation scraped off with a knife, ground in a mill, soaked in water and washed. The pure animal resin thus obtained is mixed with colophony and orpiment, cooked over a slow fire and drawn out into thin sheets—commercially known as shellac.

Within the last decade the industry has passed through various vicissitudes. It has brought ruin to more than it has benefited, and the pity is that up to the present time the causes which have brought about such a state of affairs have not been well understood. No doubt, over-production and the consequent over-stocking of the Continental and the American markets have contributed to a large extent to the lowering of the prices of the crude material from which shellac is manufactured ultimately. The prices touched their lowest point a year after the breaking out of the present war and the manufacturers as well as the cultivators in the interior of the lac-growing tracts began to think seriously of either giving up the cultivation and manufacture of shellac entirely or limiting their out-turns. In fact the prices for shellac had gone down so low—Rs. 22 a maund—that it was hardly worth while cultivating the lac. The cultivator could hardly recoup the cost of cultivation and was keenly on the look-out for something else to grow. The prices for the crude material, commercially known as stick-lac, continued to fall till July 1915, when fresh uses were found for shellac. Its export then was limited and it was declared a contraband of war. From

that date prices began to rise. Manufacturers ceased to make forward transactions and the cultivators, knowing that the prices would rise, hung on to their stocks.

There was in the phraseology of the Stock Exchange "all-round briskness." The industry seemed to have taken a new lease of life. There were enquiries for more lac all round. The manufacturer was willing to advance money on the strength of the future crop and the hitherto neglected cutltivator was the centre of attention, and he too in order to make the most of the favourable times spared no pains to collect every granule of lac wherever it could be found.

This state of affairs continued for some time, when with the steadying of prices of shellac the normal flow of the crude material again began. But in spite of all this, the actual cultivation of lac has remained as neglected as before. The experiences of 1906 and 1907 were again repeated. There was a general scramble to collect as much material as could possibly be obtained from trees large and small. Fresh and not well thought-out schemes were launched immediately and are still being continued for extending the cultivation of lac in areas where no previous cultivation has been done and where the climatic conditions which are an important factor in the development and subsequent acclimatization of the lac insect are decidedly unfavourable.

This short note has been written to draw the attention of the people who have either started the cultivation or are contemplating doing so in the future. One remarkable thing in the stimulus afforded by the present abnormal rise in prices is that a large number of persons have already either actually started cultivation or are definitely thinking of starting it in localities where success is very doubtful, and that fewer attempts have been made in localities which at present practically meet three-fourths of the demand of the world.

During the past fourteen years I have been watching closely the trend of events, and I think it is much better to concentrate attention on improving the local methods of

cultivation and storage in localities where the industry has been in existence for centuries rather than to start cultivation in localities where success is doubtful and where the moral effect of the failures is bound to act as a set-back to the budding industrialist.

As has already been stated by me in a note put before the President of the Indian Industrial Commission when he visited Pusa in November 1916, India is the only country in the world which supplies the market with shellac in its various manufactured forms, and in consequence the usual efforts have been and are being made by other countries to capture this monopoly. For the last few years the Japanese have been trying to grow lac in Formosa on *Schleichera trijuga* which abounds in the island and *kusumb** brood-lac was despatched from Pusa in crates especially made for the purpose. The plants were first potted in wooden boxes of special design to facilitate transport and, when these were established, they were inoculated with *kusumb* brood-lac and sent down to Calcutta in charge of a fieldman two months ahead of the swarming of the young lac insects. The Germans tried to experiment with lac cultivation at Amani in German East Africa. For this purpose Dr. Morstaadt took a small consignment of *ber*† brood-lac when he visited this Institute nine years ago. Some *Zizyphus jujuba* brood-lac was also taken by Dr. L. H. Gough, Entomologist, Department of Agriculture, Egypt, when he visited Pusa in 1912 in connection with the introduction of Cotton Bollworms (*Earias fabia* and *Earias insulana*) parasites into Egypt. But so far nothing is known definitely as regards the success or otherwise of these experiments. It is therefore all the more necessary to put the industry on a sound basis by organizing the cultivation on scientific lines and in consonance with the present market requirements, and to eliminate such factors as introduce an element of uncertainty into the whole business.

In years when the prices rise, as was the case from 1905 to 1907 and again during 1915 and 1916, attempts are made to oust the natural product from the market with a synthetic material. But

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* *Schleichera trijuga.*

† *Zizyphus jujuba.*

the attempts prove abortive, as the constituents of the synthetic product either cannot be obtained in bulk or the cost of manufacturing it leaves very little margin of profit to the manufacturer wherewith to push on its sale and to popularize it among the consumers of the natural product. These are some of the factors which militate against the production of the synthetic product on a commercial scale. In the country itself the short-sighted manufacturers, eager to take full advantage of the temporary rise in prices, adulterate the natural product. In fact, during years of inflated prices, the proportion of the natural product—commercially known as seed-lac—in the manufactured samples of shellac is so low that it requires great care and judgment to discriminate the pure from the adulterated product. It therefore behoves every manufacturer of shellac to stop adulteration and concentrate on the manufacture of a standard article which will be of such excellence as to effectually debar the synthetic product from competing.

A few years ago we tried to find out the reason of the partiality shown by the consumers for shellac, which even in its standard form is more or less adulterated with foreign ingredients such as colophony and orpiment, over seed-lac which is a pure animal product and in which the impurities can be easily detected. With this object in view samples of stick-lac produced at Pusa were ground in a hand mill to a standard size of grain. These were then soaked and washed with water—as per details given in *Bulletin No. 28, Agricultural Research Institute, Pusa*, (Revised edition), page 20. But before the last washing was given Monohydrated Sodium Carbonate at the rate of 8 oz. to a maund (80 lb.) was added. The alkali was mixed thoroughly with the hand in the churning vats and when the desired softness was felt water was added and strained through wire-gauze sieves of graded meshes. The washed material was aerated in the shade and was frequently turned over to dehydrate it completely. This was repeated daily until the resultant product was a beautiful pale brown in colour considerably superior to the seed-lac obtained without the addition of the alkali. The treated samples were sent to Messrs. Parsons & Keith, London,

and their report on the samples sent is quoted below *in extenso* :—

			Remarks
Kusumb (Schleichera trijuga)	Untreated	... 45s. per cwt. =Rs. 24-11-3 a md. (82 lb.)	Good quality, only a limited sale.
	Treated	... 85s. per cwt. =Rs. 46-10-9 a md. (82 lb.)	Very fine, bold clean seed-lac. We have not seen any as good as this before here. There would be a good ready sale if the price could compete with fine orange shellac and Karachi seed-lac. In Karachi there is a fairly large business done, but this quality would be preferred by buyers.
Palas (Butea frondosa)	Untreated	... 35s. per cwt. = Rs. 19-3-6 per md.	Small stick-lac, not very saleable.
	Treated	... 75s. per cwt. =Rs. 41-2-11 per md.	Good quality, pale seed-lac, rather small. The same remarks apply to this.

* * * * * * * * * *

"Before speaking with absolute certainty, we shall have to test the samples marked 'treated' to see that they are saleable, but judged by their appearance buyers seem to be taken with the treated samples, especially the Kusumb. This class of lac has only been shipped here in small quantities so far from Mirzapore, and it occasionally fetches a high price for special purposes. To be sold in large quantities it would have to compete with shellac and the price would vary with the price of shellac.

"We believe the treated would meet with a ready market and would fetch, roughly speaking, double the price of the untreated. Based on the present price of shellac, we think you could safely reckon to sell the Kusumb treated in quantity at 85*s*. per cwt., and the Palas treated at 75*s*. per cwt. We should recommend a trial shipment of 20 to 25 bags of each quality."

From further trials made at Pusa it was found that if a larger quantity of Monohydrated Sodium Carbonate than that stated above was added or if the alkali was allowed to remain in contact with the animal resin for more than 5 to 10 minutes, the natural wax surrounding the grain of lac was washed away and the resultant product was rather rough and crisp to the feel. From figures obtained through the courtesy of Messrs. Moran & Co., Brokers,

Calcutta, the total quantity of shellac exported from Calcutta during the past twelve years, 1905—1916, was :—

	Cases	Weight in maunds (80 lb.)	Price per md.			Total value		
			Rs.	A.	P.	Rs.	A.	P.
1905	157,536	339,840	87	0	0	32,264,080	0	0
1906	156,502	391,255	107	0	0	41,864,285	0	0
1907	206,789	516,972	102	0	0	52,731,144	0	0
1908	222,112	555,280	57	8	0	31,928,600	0	0
1909	322,006	805,015	37	8	0	30,188,062	8	0
1910	289,996	724,990	40	8	0	29,362,095	0	0
1911	235,339	588,347	37	0	0	21,768,839	0	0
1912	254,141	635,352	34	0	0	21,919,644	0	0
1913	191,993	479,982	46	0	0	22,062,842	0	0
1914	231,831	579,627	35	8	0	20,576,658	8	0
1915	243,502	608,755	34	0	0	20,697,670	0	0
1916	236,681	591,702	55	0	0	32,543,610	0	0
		6,817,117				357,907,530	0	0

Thus on an average over five and a half lakhs of maunds of shellac worth about three crores of rupees have been sent out yearly from the port of Calcutta alone. Had similar figures been obtainable for the ports of Bombay and Karachi it would have been found that over seven lakhs of maunds of shellac, worth over four crores of rupees, must have been exported from the country annually. Had this quantity been treated as already described above, there would have been a net saving of thirty to thirty-five lakhs of rupees, besides yielding a large quantity of lac-dye which might have been standardized to a paste to facilitate transport and to yield a colouring matter which, with proper mordants, might have produced from light to fast colours.

At the present time when the prices of shellac are oscillating to such an extent, with a general tendency to rise, as will be seen from the weekly quotations taken from Messrs. Moran & Co.'s weekly shellac reports,* it would be worth while sending trial

*

	T. N.	Superfine
9th January, 1918	92	120
16th ,, ,,	91-92	120
23rd ,, ,,	92-92/8	120
30th ,, ,,	93-96	120
6th February ,,	93-96	120
13th ,, ,,	93-96	120
20th ,, ,,	97-98	125
27th ,, ,,	97-99	125
6th March ,,	97-99	125
13th ,, ,,	99-101	125
20th ,, ,,	100-102	125

shipments of seed-lac treated as noted above. In the beginning the new brand may be expected to meet with some opposition, as trade prejudices, however peculiarly they might have become grafted in practice, die hard; but if the quality of the new brand be maintained at a uniform standard, it is expected that the consumers would gradually take to it and would give up the use of the shellac in its present adulterated forms. This change would do away with the necessity of storing stick-lac in bulk and thus allowing it to get "blocky" or "coagulated." And this is not a small item as every manufacturer would testify from his bitter personal experience as to the cost of storing the stick-lac in bulk and preventing it from getting spoiled by insects which feed exclusively on the stored material irrespective of those which spoil the produce on the trees. No doubt, with a little attention to details, this loss can be prevented easily by clearing the godowns annually and fumigating them either with carbon bisulphide (vide *Bulletin No. 28, Agricultural Research Institute, Pusa*, Appendix C) or with flowers of sulphur at the rate of 4 lb. per 1,000 cft. of space. Before fumigating, the godowns should be cleaned thoroughly and no stray lumps of worm-eaten blocky-lac should be allowed to lie about the interior. All old burrows, pits in the floor, and crevices in the walls should be plastered over and the doors and the windows made airtight as far as possible. The weighed quantity of sulphur should then be placed in the rooms in earthen pans containing water to catch the overflow and the mass ignited. Doors and windows should then be closed and allowed to remain so for 24 hours, when they may be opened to let in fresh air.

In order that a sufficient quantity of stick-lac should be readily available in the market, it will be necessary to improve the methods of cultivation practised in the different parts of the country. Prior to 1908 when lac-dye was a marketable item of considerable importance it paid the cultivator as well as the manufacturer to pay for stick-lac which was rich in colouring matter. But now with the introduction and extensive use of aniline and other dyes, lac-dye has sunk into insignificance and is not of much commercial

importance. With this change in the market the cultivator has not kept himself in touch. He still follows the old antiquated system of removing lac before swarming has taken place. This, though it does not directly benefit him now, is at the bottom of the shortage in the supply of the crude material, and in spite of the prolific growth of the lac insect it has not been able to hold its own against the increase of parasites, predators, and other factors which restrict its growth. It is therefore but proper that steps should be taken to remedy these defects and to bring home to the cultivator that it no longer pays either him or the manufacturer to collect lac rich in colouring matter. This can be avoided easily by removing all the lac from the trees a fortnight before the swarming takes place and putting it on trees already pruned for the purpose. The *ber* and the *palas* * stand pruning well and with judicious and seasonable pruning their life and vitality could be increased considerably—the prunings may be utilized either for charcoal making or for fencing cattle enclosures. Our experience for the past fourteen years shows that the produce from pruned trees is richer in resinous contents than that obtained from unpruned trees and that the successive broods reared on pruned trees are not so liable to disease as is otherwise the case. The present is a very opportune time to bring about these changes in the methods of cultivation, as with the high prices prevailing for shellac and in proportion for stick-lac for the last three years the cultivator has been able to recoup the losses sustained prior to 1915 and can well afford to spend a fair portion of his profits in renovating the trees either by pruning them or by making fresh plantations divided into blocks for the yearly and systematic production of lac. Besides this, he should also see that only healthy brood-lac is brought and put on the trees. This he can do easily by consulting the Plates XIII and XIV, in *Bulletin No. 28, Agricultural Research Institute, Pusa* (English and Hindi editions). He should also avoid bringing or purchasing brood-lac from localities where parasites and predators are present in large numbers and thereby running the risk

* *Butea frondosa.*

of introducing them into new localities. Once these are established it is not only difficult but also expensive to eradicate them effectually. He should also arrange for occasional exchanges. Brood-lac from hilly tracts is more vigorous than that grown in the plains from year to year. While purchasing he should also see that the brood-lac which he wishes to put on his trees is obtained from a locality or localities where the climatic conditions are as similar as possible to those obtaining in his place. It is no good obtaining brood-lac from the borders of Nepal and experimenting with it at Allahabad or Gwalior. Such trials are bound to end in failure, and should as far as possible be avoided. Further, it is much better to use *palas* brood-lac on *palas*, *ber* on *ber*, *kusumb* on *kusumb*, and brood-lac from Ficus species on Ficus species. Though *kusumb* brood-lac is the hardest of all, yet from further observations it has been found that it is from business considerations safer to abide by the amended note given above.

At present the distribution of lac cultivation in India is practically as shown in the map. In Sind the lac insect flourishes best on the *babul* (*Acacia arabica*), and over three-fourths of the quantity collected and exported from Karachi is obtained from this source. *Palas* lac is mostly obtained in parts of the United Provinces, Bihar and Orissa including Mourbhanj, Central India, Rewah, Nagode, and Maihar, the northern and the south-eastern parts of the Central Provinces, some parts of Bengal and Bombay—Panch Mahals, Ali Rajpur and Deogad. *Ber* lac grows spontaneously in the Punjab and is cultivated at Rungpur, Murshidabad and Dumkah in Bengal, and Manbhum in Bihar and Orissa. *Kusumb* lac is obtained in bulk from the Chota Nagpur Plateau and the Chhattisgarh Division in the Central Provinces, though it is more or less collected in almost all the lac-producing tracts in India. Large quantities of lac on Ficus species are obtained from Assam, where it is also grown in the Garo and the Khasi Hills on *mirimah*—a variety of *tur* (*Cajanus indicus*).

With such diversity in the foodplants of the lac insect, much difficulty has been experienced in the past in obtaining healthy

brood-lac at proper times for starting cultivations or making trials as regards the suitability or otherwise of the lac insect in new localities. The cultivators have hitherto neglected this source of income. The prices for the brood-lac and the subsequent transport charges have been so exorbitant in the past that it has not paid at all to start cultivation in new localities. If, however, suitable distributing centres are established in favourable localities, new areas—hitherto of no economic use to their owners—will be tapped yielding large and fairly constant quantities of stick-lac which will have the effect of steadying the prices of shellac if other factors remain normal. By the establishment of such nurseries vast areas overrun with *palas*, especially in the United Provinces, Central India, the Central Provinces, and Bihar and Orissa, will become productive and will benefit directly the rural population of such areas. For the present the establishment of a dozen nurseries distributed as follows would be ample :—

Sind	2 nurseries.	For the supply of *babul* brood-lac.
Central India	2 ,,	For the supply of *palas* and *kusumb* brood-lac.
Bombay	1 nursery.	
C. P. and Berar	2 nurseries.	
Bihar and Orissa	2 ,,	
United Provinces	2 ,,	
Bengal	1 nursery.	For *ber* brood-lac.

By some such arrangement the difficulties of transport would be considerably lessened, and the growers would have the assurance of obtaining healthy brood-lac at the proper time and at reasonable prices.

RECENT INVESTIGATIONS ON SOIL-AERATION.*

PART I. WITH SPECIAL REFERENCE TO AGRICULTURE.

BY

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I. Introduction.

The growing of a crop is an exercise in applied physiology. This operation, as is well known, is only possible through the simultaneous operation of a number of soil factors—water, mineral salts, temperature and oxygen. What is not always fully realized is that if any one of the factors concerned, for example, the supply of combined nitrogen, is in defect, growth is checked and stops altogether when this substance is no longer available. Nitrogen is then said to be a limiting factor in growth. On the addition of a further supply of this substance, growth at once re-commences and proceeds till the crop is ripe unless some other factor becomes deficient. A crop, limited in growth by a deficiency in the supply of any particular factor, is not influenced by the increase of other factors. Thus a shortage of combined nitrogen is not made up for by the application of phosphates or potash or by increased irrigation. Just as the strength of a chain is limited by that of its weakest link, so the growth of a crop depends on the factor in greatest defect.[1] The chief object in soil-management is the removal, in advance, of any possible limiting factor which may operate adversely.

The aeration of the soil is a factor in growth which has been greatly neglected in the past. The three substances involved—oxygen, nitrogen, and carbon dioxide—are gases which are invisible and are not on the market in the form of artificial manures like nitrate of soda or superphosphate of lime. Only very indirectly has soil-aeration been recognized in the European literature on agriculture

* A lecture delivered to the Indian Science Congress on 9th January 1918.

[1] In the case of the temperature factor, growth is also limited when the optimum is exceeded.

in the importance attached to a proper soil texture. Soil texture is really important because of its influence on soil-aeration. In this lecture it is proposed to refer to some of the recent work on soil-aeration and to indicate the direction in which further investigation is needed particularly in the irrigated tracts of India.

II. Aeration and the Amount of Growth.

If growth is influenced by the aeration of the soil, the effect of this factor should be apparent in any series of cultures where all the conditions are uniform except the ventilation of the roots. A number of investigations have recently been carried out on this point from which the following examples are taken.

1. *The effect of increased aeration on the root development of barley.* This matter is dealt with in one of Mr. Hall's papers in the *Philosophical Transactions* (B, vol. 204, 1913). One example taken from this paper will suffice.

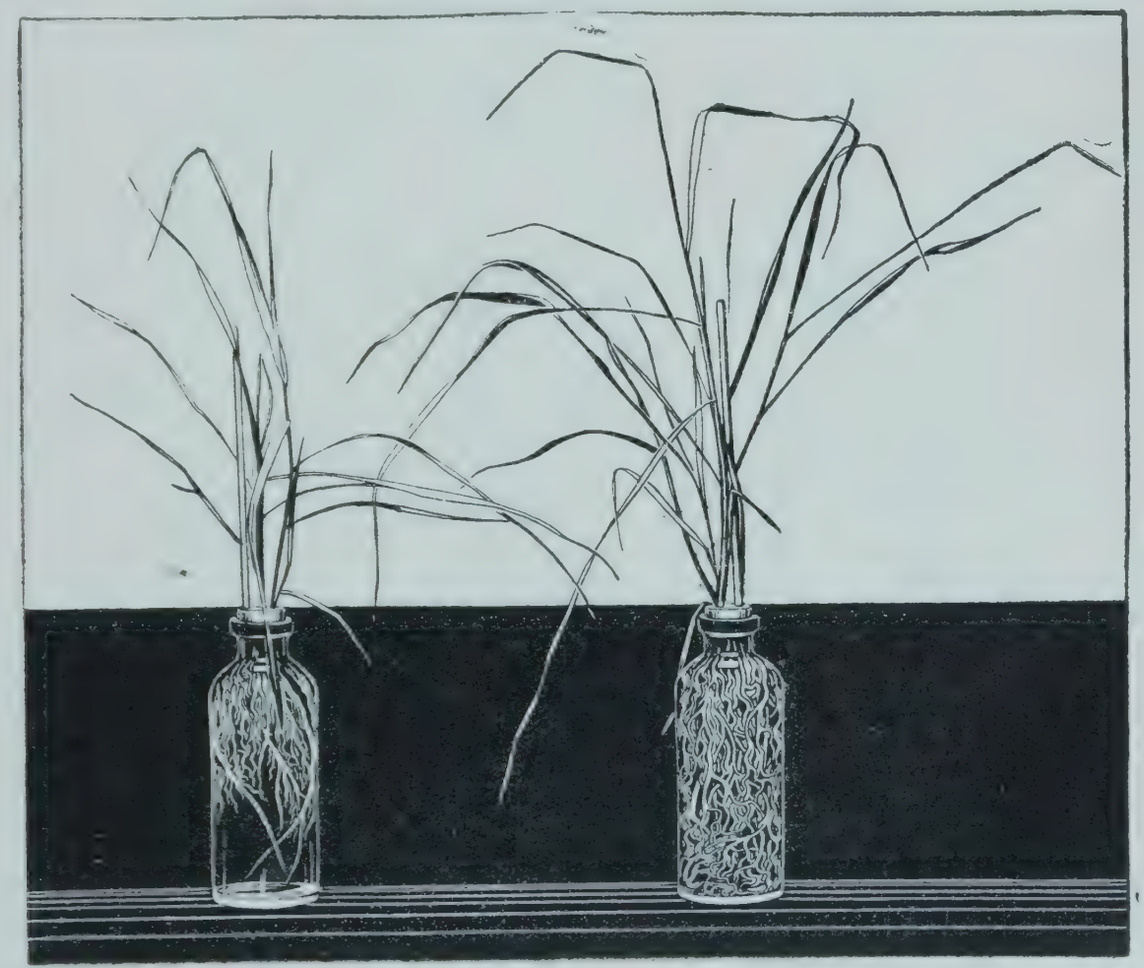


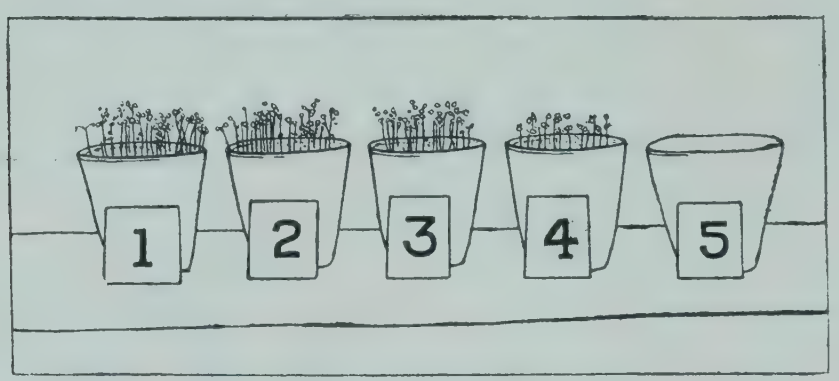
Fig. 1. Growth of barley in solutions aerated once a day (left) and aerated continuously (right).

On the screen are represented two water cultures of barley (Fig. 1). The bottle on the left was aerated once a day, that on

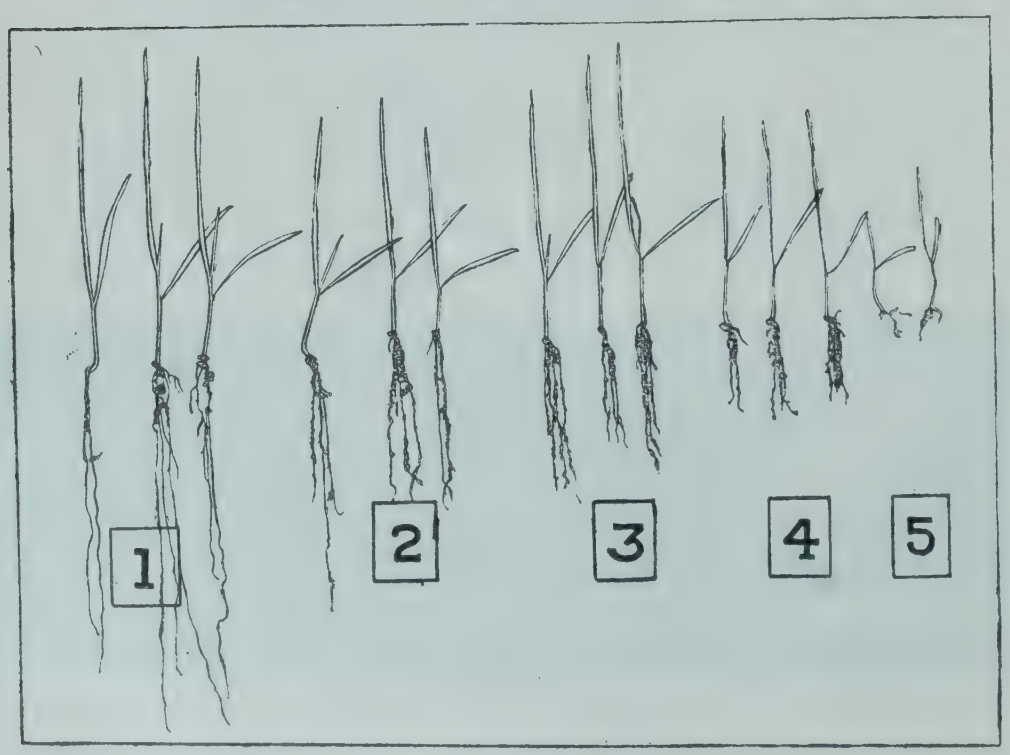
the right was aerated continuously. It is clear that both root development and growth depend on the amount of aeration.

2. *The effect of soil texture on growth.* The results published by Mr. Hunter in Vol. IV of the *Proceedings of the Philosophical Society of the University of Durham* show the marked effect of soil texture on growth. Various kinds of soil were used and the plants selected were sunflower, peas, wheat, and cress. Five degrees of soil texture were adopted as follows :—

1. Soil in small lumps, loose.
2. Soil fine, loose.
3. „ „ firm below, with a loose surface.
4. „ „ firm.
5. „ „ hard.



SEEDLINGS OF LEPIDIUM SATIVUM.

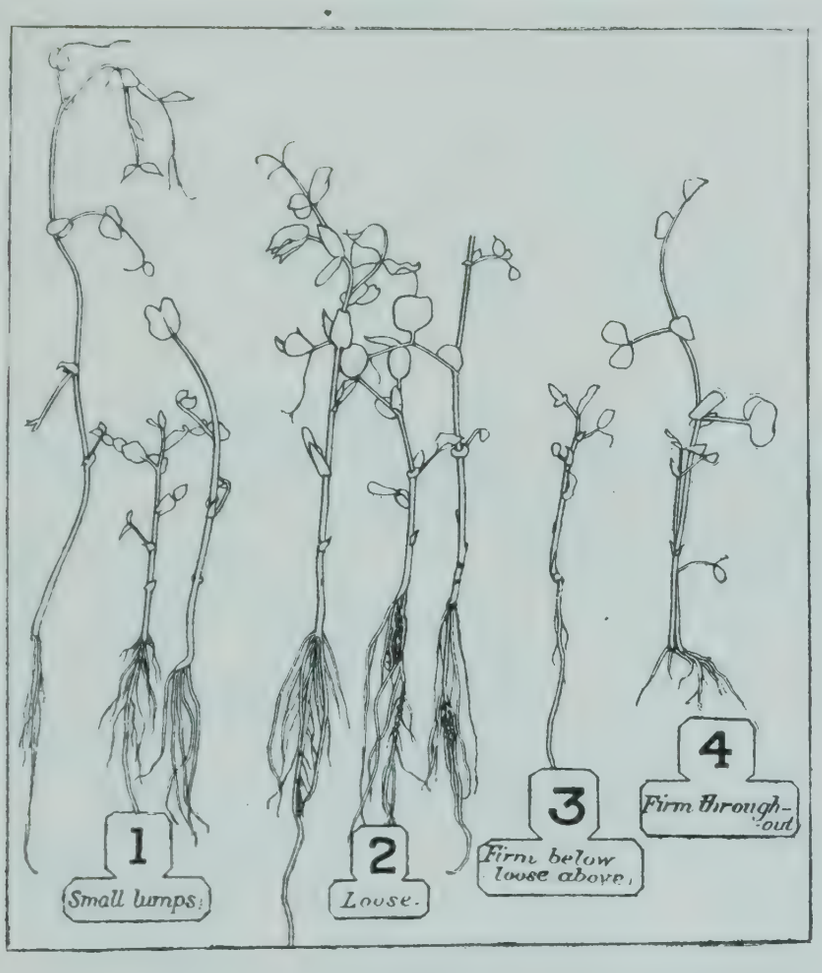


WHEAT PLANTS.

Fig. 2. The effect of soil texture on the growth of cress and wheat.

The results obtained are shown on the two following slides (Figs. 2 and 3).

The first (Fig. 2) shows the effect of soil texture on the growth of cress and wheat. Where the soil was hard, the cress seeds did not germinate. In the case of wheat, the effect of the texture on root development is very clear. The closer the packing, the poorer the growth. The corresponding results with peas are shown on the next slide (Fig. 3).



PISUM SATIVUM.

Fig. 3. The effect of soil texture on the gr wth of peas.

Here the best growth was obtained where the soil was fine and loosely packed. Mr. Hunter next measured the effect of soil texture on the resistance to an artificial air current. It was found that the resistance of columns of soil was in accordance with their textures. The results are to be seen in the table on the screen (Table I).

TABLE I.

Soil texture and air movement.

Description of soil	Height in cm.	Resistance offered
1. Small lumps, loose	35	1 unit
2. Fine, loose	35	2 units
3. Fine, firm below with loose surface	5 loose 30 firm	17 ,,
4. Fine, firm throughout	35	42 ,,
5. Fine, hard throughout	35	310 ,,

3. *The effect of adding potsherds or sand to the Pusa soil.*[1] The soil at Pusa is a calcareous silt which readily forms a surface crust and often loses its texture altogether after long continued heavy rain. The addition of one inch of potsherds to the heavy soils of the Botanical area increases the yield considerably. Some of the results obtained are given in Table II.

TABLE II.

The effect of diluting Pusa soil with potsherds or sand.

1. Wheat, oats, and tobacco.

Crop	Yield per acre of control plot	Yield per acre with one inch of potsherds	Increase per acre	Percentage increase
	m. s.	m. s.	m. s.	
Oats	24 17	28 36	4 19	18
Wheat	16 18	19 30	3 12	20
Tobacco	21 0	23 3	2 3	10

2. Indigo.

Kind of soil	No. of plants measured	Average length in cm.	Percentage increase
Soil only	33	36·7	0
50% Soil + 50% sand	36	51·6	40
90% Soil + 10% potsherds	33	48·3	31
70% Soil + 30% potsherds	35	50·9	38

These examples, selected from many others, are sufficient to illustrate the main fact that soil-aeration is one of the factors on which the growth of plants depends.

[1] Howard, A. *Bulletin 61, Agr. Res. Inst., Pusa,* 1916.

The structure of the soil.

To follow the subject further, it is necessary to consider the structure of the soil and the relation of this structure to the root system of the plant. The soil consists of particles with intervening spaces between them known collectively as the pore space. For every soil, the proportion of the volume of this pore space to the total volume of the soil varies with the closeness of packing. When the soil texture is good, the pore space is large. After heavy rains and when waterlogged, fine silt-like soils run together into a condition of close packing when the pore space is considerably reduced. Thus the volume of the pore space varies according to circumstances. The pore space is taken up by two things—water and air. The water occurs in thin films round the soil particles, while the soil air fills up the rest of the pore space. The next slide (Fig. 4) represents the structure of the soil, in relation to the root-hairs of a crop.

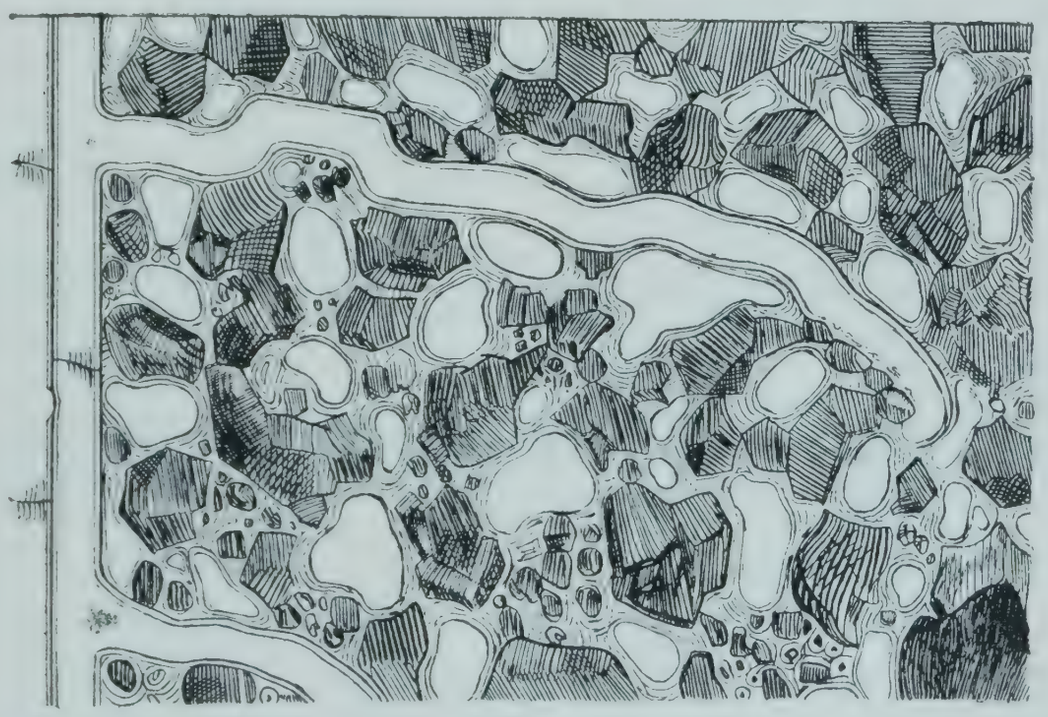


Fig. 4. The soil in relation to the root-hairs of a plant. The solid soil particles are darkly shaded, the air spaces are white, the adherent water is indicated by concentric lines. From the piliferous layer of the root two root-hairs arise. (After Sachs.)

In the water films round the particles there is intense biological activity. New root-hairs are constantly being produced by the plant, which, for a time, absorb water and dissolved materials and then die. Various soil bacteria are occupied in the decomposition

of organic matter. Both these activities involve the process of respiration. The working protoplasm in each case uses up oxygen, and carbon dioxide is produced as a by-product. The soil atmosphere is therefore constantly being called upon to supply oxygen for respiration and receives fresh supplies of carbon dioxide. Efficient ventilation is clearly essential if the air in the pore spaces is to be kept fresh. Supplies of oxygen must pass into the soil

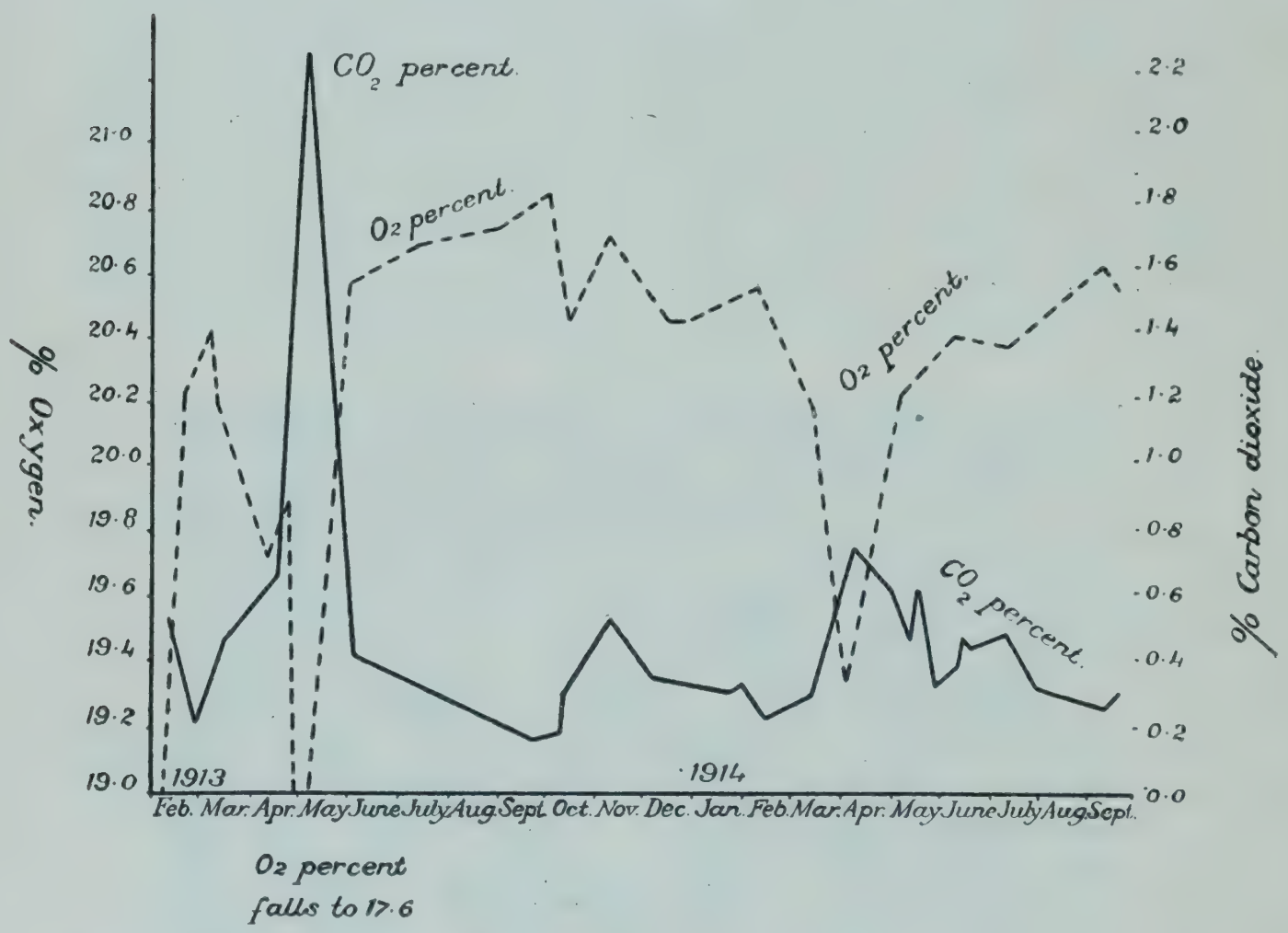


Fig. 5. Curves showing percentages of CO_2 and of O_2 in soil air in Broadbalk dunged plot.

from the atmosphere and at the same time the excess carbon dioxide in the pore spaces must diffuse out in the reverse direction. The pore spaces are the living rooms of a vast underground city the inhabitants of which require fresh air.

It is only very recently that investigators have begun the systematic study of the soil atmosphere in relation to the biological activities proceeding in the soil. Important and interesting results

are being obtained at Dehra Dun by Messrs. Hole and Puran Singh, and at Rothamsted by Dr. Russell and his colleagues, some of which have been published. In general, Dr. Russell and Mr. Appleyard[1] find that the oxygen and carbon dioxide curves are reciprocal—the oxygen falls as the carbon dioxide rises. The agreement is sufficiently close to justify the assumption that the oxygen is mainly used up in producing carbon dioxide. One of these curves is shown in the next slide (Fig. 5).

These investigations also throw considerable light on the composition of the gases dissolved in the water films. These contain very little oxygen but a great deal of carbon dioxide as will be evident from the figures in the next slide (Table III)

TABLE III.

Composition of gas held absorbed by soil. Percentage by volume.

	Weight of soil used, grm.	Percentage of moisture	Approximate volume of gas removed in successive extractions	Percentage composition of gas		
				CO_2	O_2	N_2
Pasture soil	352	28	1st 30 c.c.	52·0	0·7	47·3
			2nd 30	84·8	0·2	15·0
			3rd 22	99·1	0·2	0·7
Soil covered with vegetation (Broadbalk wilderness) ...	400	22	1st 30 c.c.	19·3	5·5	75·2
			2nd 30	57·0	2·6	40·4
			3rd 15	98·7	0·2	1·1
Rich garden soil	468	20	1st 30 c.c.	89·5	0·2	10·3
			2nd 30	99·3	0·0	0·7
			3rd 15	94·4	0·0	5·6
	extracted later		4th 30	96·8	0·0	3·1
			5th 30	92·3	0·0	7·6
Arable soil Broadbalk dunged plot.	...	24	1st 30 c.c.	10·8	4·4	84·8
			2nd 30	57·9	1·8	40·3
			3rd 15	98·4	0·0	1·6
Broadbalk unmanured ...	497	16	1st 30 c.c.	6·3	15·1	78·6
			2nd 25	40·2	9·7	50·1

The essential point is that the water films are exceedingly poor in oxygen but very rich in carbon dioxide. As they are the seat of an intense biological activity for which oxygen is essential, it is clear that the consumption of oxygen in the film is equal to the rate at which it is renewed. The details relating to the gaseous exchanges between the pore spaces and the water films need much more investigation and a further contribution has been promised

[1] Russell, E. J., and Appleyard, A. *Jour. of Agr. Sc.*, VII, p. 1, 1915.

by Dr. Russell. On physical grounds, we should expect that the water films would derive their supplies of fresh oxygen from the air in the pore spaces. The Rothamsted experiments, however, have drawn attention to another source, namely, the oxygen dissolved in the rain water[1]. Rain was found in most cases to be a saturated solution of oxygen which stimulated markedly the biological activities in the soil. The effect of showers of rain was found to be greater than that produced by water alone and could be explained by the influence of the dissolved oxygen in replenishing the supply of this substance in the water films. That rain benefits crops has long been known and practical men have always felt that something more than a moisture effect is concerned. We realize now that rainfall supplies not only water but also oxygen in the most effective form. In future, we must think of the Indian monsoon not as the distribution of so much rainfall over certain areas but rather of so much water rich in dissolved oxygen.

It will now be clear that one of the essentials for the growth of plants is the maintenance of the oxygen supply of the pore spaces and of the water films round the soil particles. The soil must be kept ventilated or the denizens of our underground city will languish for want of air. Let us study the ventilation of our underground city in connection with flood irrigation as practised by the cultivators all over Northern India. The soil is alluvial in nature. Its texture deteriorates if it is flooded with water. As it dries under the hot sun, the surface bakes into a crust largely impermeable to air. That the crust is impermeable can be seen by immersing in water a portion of the hardened surface soil after irrigation. The air escapes sideways not through the surface skin. Each successive irrigation destroys the soil texture still more and the surface crust becomes more and more impermeable to air. The effect of irrigation on alluvial soil therefore interferes with its ventilation. The process removes one limiting factor, the want of water, but it introduces another, namely, the need of aeration. That this is so will be clear from Table IV which contains the result of a recent experiment at Quetta.

[1] Richards, E. H. *Jour. of Agr. Sc.*, VIII, p. 331, 1917.

TABLE IV.

The introduction of a new limiting factor after irrigation.

Number of waterings	Area in acres	Total weight of produce	Total weight of grain	Yield of grain per acre	Percentage reduction
		lb.	m. s.	m. s.	
One	3·99	10,367	52 6	13 2	0
Three	2·65	6,620	25 15	9 23	26

Here the last two irrigations reduced the yield through the introduction of another limiting factor—the need of soil-aeration. Clearly if we could work out a practicable compromise between the needs of the soil for water and for air under irrigated conditions, an immediate advance in agriculture would result. This has recently been accomplished at the Quetta Experiment Station. I propose to indicate briefly the manner in which it was done. The Quetta valley is typical of the upland valleys of Baluchistan. The soil resembles that of the plains of India and the characteristic of the climate is the dryness of the air and the amount of air movement. It is a dry, windy place. Irrigated crops therefore require an enormous quantity of water. Irrigated wheat is often watered six times and the crop shows all the symptoms of poor soil-aeration—excessive liability to rust attacks, slowness in ripening, and shrivelled grain of poor quality. The irrigated wheat dries up rather than ripens and the bright straw and shining chaff which are so characteristic of this crop are not developed in the Quetta valley. It was obvious that enormous quantities of valuable irrigation water were being thrown away to no purpose on the wheat crop. A method of growing the crop on a single irrigation was worked out which is now being taken up by the cultivators. The method consists in making full use of the preliminary irrigation before sowing and the breaking up of rain crusts afterwards. The details of the method are to be found in the bulletins[1] issued by the Quetta Experiment Station. Under the new method, the yields are often higher with one irrigation than with six or seven. Harvest is about a month

[1] Howard, A., and Howard, G. L. C. *Bulletins 4 and 7, Fruit Experiment Station, Quetta*, 1915 and 1917.

earlier and the wheat ripens normally and develops the characteristic colour of the chaff and straw.

As the wheat crop on the Canal Colonies of the Punjab also exhibits definite signs of want of soil-aeration during the ripening period, I ventured to predict that at least one-third of the irrigation water now used on this crop is wasted. The matter was put to the test of experiment during the wheat season of 1916-17. The Punjab results are given in Table V.[1]

TABLE V.

Results of water-saving experiments on wheat (*Pusa* 12), *at Gungapur, Haripur, and Sargodha in* 1916-17.

Station	No. of irrigations including the preliminary watering	Yield per acre				Average yield per acre			
		Grain		*Bhusa*		Grain		*Bhusa*	
		m.	s.	m.	s.	m.	s.	m.	s.
Gungapur	One	12	19½	20	10	9	34	21	17
Haripur	,,	8	31	19	14				
Sargodha	,,	8	12½	25	27½				
Gungapur	Two	18	0	25	8	16	11	25	5
Haripur	,,	15	21	23	16				
Sargodha	,,	15	12½	26	32½				
Gungapur	Three	14	25	18	0	15	11	22	2
Haripur	,,	16	8	26	4				

An inspection of the figures shows very clearly that after the second irrigation water ceased to be a limiting factor and then began to depress the yield. Similar but still more striking results were obtained by Mr. Main at Mirpurkhas in Sind. The significance of these results will be apparent when it is remembered that the annual revenue derived from irrigation works in India is about £5,000,000 sterling. Taking the Indian Empire as a whole, there can be no question that the water wasted every year would, if used to the best advantage, bring in a very large direct and indirect revenue to the State.

[1] Annual Report of the Imperial Economic Botanists, 1916-17. *Scientific Reports of the Pusa Agr. Res. Inst.*, 1916-17.

III. Soil-Aeration and Quality.

The quality of vegetable products, as is well known, varies greatly with the locality. The quality of the wines of Champagne and of the tobacco grown on certain soils in Cuba depends to a great extent on the soil of these tracts. The transference of the vines of Champagne or of the tobacco plants of Cuba to other places does not mean the transfer of the special qualities associated with the wine and cigars produced in these localities.

What are the factors on which quality depends ? The breed or variety is certainly one. A rough, short-stapled cotton, for example, can never be transformed by alteration in the environment so as to resemble the best Egyptian or Sea Island types. Such a cotton can be improved to a limited extent but the fibres will always remain coarse and short. It is suggested that besides the variety, quality also depends on another factor, namely, adequate soil-aeration. Many examples can be quoted in support of this view. It will be sufficient to mention the following :—

1. *Barley.* The barley crop is grown all over England, the best samples being used for making malt. For the best beer, the barley grain must be well filled with starch so as to produce a rich, clear malt-extract. Such barleys are always grown on light land where the natural aeration of the soil is good and where the crop ripens off quickly. On stiffer soils, the aeration is bad, the barley ripens slowly and the grains are often poorly filled with starch. Maltsters do not like these barleys as they give a thin, cloudy extract.

2. *Tobacco.* As is well known, the internal tobacco trade of India is enormous. Certain tracts such as the Parganah Saraisa in Tirhut, Jais in the District of Rae-Bareli, and the Mustung valley in Baluchistan have achieved a reputation for quality which is well known in the trade. In all these places, the soils which produce the best qualities are those in which the aeration is much above the average.

3. *Cotton.* Recent investigations in the Central Provinces indicate that soil-aeration is one of the factors on which the staple

of cotton depends. Mr. Clouston has shown that on the open laterite plains near Raipur where the soil is such that its texture cannot be destroyed by heavy rain or surface flooding, long staple cotton of high quality can be produced. Further, the fibre of coarse cotton like *roseum* is improved when this type is grown on these laterite soils. Similar results are obtained with other crops like groundnuts and sugarcane.

No scientific explanation of the part played by soil-aeration in the development of quality has yet been put forward. The recent Rothamsted results however appear to throw light on this point.[1] If we compare the carbon dioxide in the soil atmosphere from cropped and uncropped land, two marked differences disclose themselves. The curves are to be seen on the last slide (Fig. 6).

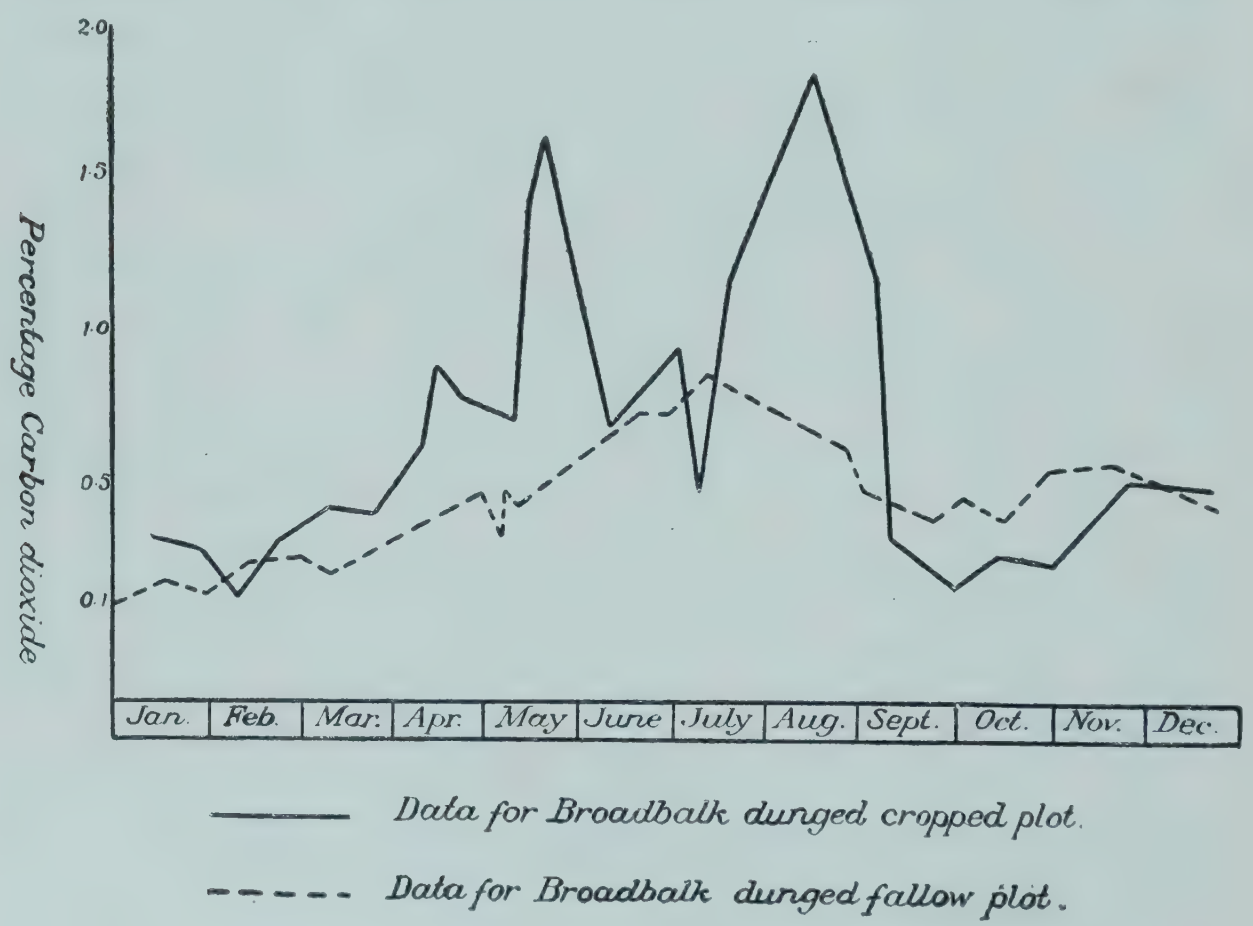


Fig. 6. Percentage of carbon dioxide in the soil air of dunged fallow and of dunged crop land.

During the rapid growth of the wheat crop in May and during the whole of the ripening period in August there is a great outpouring of carbon dioxide. This is produced at the expense of the oxygen

[1] Russell, E. J., and Appleyard, A. *Jour. of Agr. Sc.*, VIII, p. 385, 1917.

in the soil air. It is easy to understand the great production of carbon dioxide in May. This is associated with the intense biological activity in progress in the soil at this period. It is not so easy to understand why so much oxygen is required during ripening and why so much carbon dioxide is produced. In India experience teaches us that crops never ripen properly if the soil-aeration is interfered with during this period. A part of the explanation is probably to be found in the fact that the fine roots begin to die and decay after the flowering period, but this does not explain why the crop will not ripen unless air is supplied. The changes in the soil air during the life of the crop have so far not been investigated in India. A splendid field of applied research lies untouched which is bound to yield a rich harvest of results.

IV. Some other Aspects of Soil-Aeration.

It follows that if soil-aeration is a growth factor, aeration must influence the distribution of plants[1] and prove to be of importance in ecological studies. Attention is now being paid to this aspect of the subject and results are beginning to appear. In the United States, Professor Cannon of the Desert Laboratory in Arizona and Professor Free of the Johns Hopkins University find that an inhibition of root growth is caused in numerous plants by a decreased amount of oxygen in the soil atmosphere.[2] The poor conditions of soil-aeration are correlated with the absence of vegetation in the dry lakes of desert basins and the zonation of vegetation around these basins is possibly in correlation with the different soil-aeration requirements of the plants involved. Professor Cannon intends to visit India and to pursue his studies in this country.

In India also, Mr. Hole has shown that soil-aeration is an important factor influencing the distribution of woodlands and grasslands. As regards the general importance of soil-aeration in Indian forestry, Mr. Hole has kindly promised to place his views before the Congress.

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[1] The distribution of gram in India is correlated with soil-aeration. See *Agr. Jour. of India*, Special Indian Science Congress Number, p. 20, 1917.

[2] Cannon, W. A., and Free, E. E. *Jour. of Ecology*, V, p. 127, 1917.

PART II. WITH SPECIAL REFERENCE TO FORESTRY.

BY

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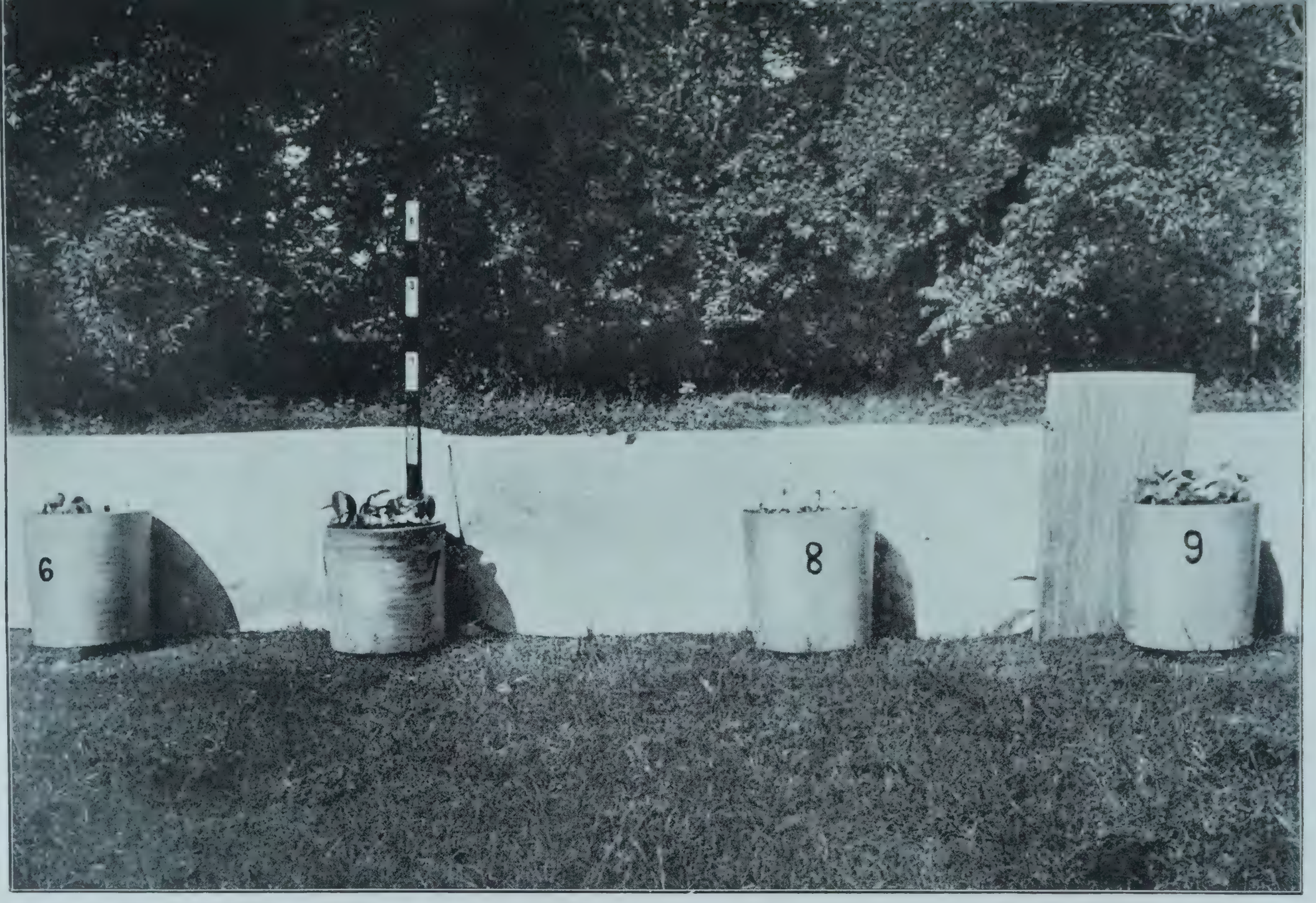
Mr. Howard has just emphasized the importance of soil-aeration in Indian agriculture, and I hope to convince you that it is no less important in Indian forestry.

As we frequently have great difficulty in quickly establishing a vigorous growth of seedlings in our valuable *sal* (*Shorea robusta*) forests, a study of the factors influencing germination and the development of seedlings was commenced at Dehra Dun in 1909. Preliminary pot experiments carried out in 1909-10 showed that, whereas it was practically impossible to injure *sal* seed or seedlings by watering in sand into and through which water percolated rapidly, germination could be materially reduced and the seedlings rapidly rendered unhealthy in water-retaining loam and leaf-mould by keeping the soil constantly moist. It was immaterial whether this moist condition was produced by the addition of water to the soil or by diminishing the loss of water from the soil through evaporation or percolation. The injurious action was most severe in the leaf-mould which contained considerably more organic matter than the loam.[1] Similar results were subsequently obtained with loam taken from a local *sal* forest.[2] In the latter soil the injurious action can be strikingly demonstrated by growing the plants in non-porous glazed pots, the drainage holes at the base of which are subsequently closed by corks when the seedlings are well established. In such cases, while evaporation can take place freely from the surface of the soil, no evaporation is possible from the sides of the pots and the water falling on the soil surface accumulates at the base of the pot, thus forming an artificial water table at the base of the pot. In such cases when the pots are placed in full sunlight

[1] *Indian Forest Records*, vol. 4, part I, pp. 17, 19 (1914),

[2] *L. c.*, p. 30.



Photograph taken 20th September, 1915, showing Sal seedlings growing in Sal forest loam. Note the healthy growth in the uncorked pots 7 and 9, as compared with that in pots 6 and 8 which were corked on 30th July, 1915.

Fig. 1. Several of the Sal seedlings in pots 14 and 19 have shed their leaves as a result of placing dead Sal leaves on the surface of the soil. In pots 15 and 18 to which no dead leaves were added the seedlings are quite healthy. Photograph taken $3\frac{1}{2}$ months after the dead leaves were added.

Fig. 2. Photograph of the pots shown in Fig. 1 above taken one month later. Nearly all the seedlings in pots 14 and 19 have now shed their leaves.

in the open and supplied only with the local rainfall, the seedlings begin to get unhealthy in about 10 days and, unless the conditions are altered, eventually die.

Plate XXIV shows *sal* seedlings growing under these conditions, pots 7 and 9 being uncorked while 6 and 8 have been corked for 52 days. Previous to corking, the number of healthy plants in 7 and 9 was exactly the same as that in 6 and 8. Note the healthy plants in 7 and 9 as compared with those in 6 and 8.[1] Similar results can, however, be produced by a procedure which to some extent is the reverse of the above, *viz.*, by opening the drainage holes at the base of the pots and then retarding evaporation from the upper soil surface by covering it with a layer of dead leaves.

For the purpose of this experiment seed is sown as before in the glazed pots, the drainage holes at the base of which are left open. When healthy seedlings have been thoroughly established, the surface of the soil in some pots is covered with a layer of dead *sal* leaves while no such covering is placed in the control pots. If the soil is then kept moist in all the pots, either by artificial watering or natural rainfall, the seedlings in the pots with dead leaves soon become unhealthy. Plate XXV, fig. 1 shows examples of such plants : 14 and 19 are pots with dead leaves on the surface of the soil, while 15 and 18 are pots with no dead leaves. When the dead leaves were placed in position there were 39 healthy plants in the former and 37 in the latter. The photograph was taken $3\frac{1}{2}$ months afterwards, and it will be seen that a number of the plants in the former have shed their leaves. Plate XXV, fig. 2 shows the same plants a month later when nearly all the plants in pots 14 and 19 had shed their leaves. It is interesting to note that if the pots are filled with sand instead of forest loam no injurious effect is produced by the dead leaves. Plate XXVI, fig. 1 shows *sal* seedlings growing in sand, pot 23 has dead leaves on the surface, while pot 22 has no dead leaves. This photograph was taken $3\frac{1}{2}$ months after the leaves were placed in position and no injurious effect had been produced. In these experiments the layer of dead

[1] *Indian Forest Records*, vol. 4, part III, p. 90 (1916).

leaves was six leaves thick, which is roughly equivalent to the annual leaf-fall in a well stocked natural forest.

Simultaneously with these pot experiments a series of experiments have been carried out in the Dehra Dun *sal* forests. These have shown that, whereas in the shade of the forest germination and seedling development during the rains is uniformly poor, even when the soil-covering of dead leaves is removed and the soil dug, excellent seedling growth can be obtained if the trees are felled in narrow strips or small patches and the seed then sown in the clearings where the soil is exposed to the sun and air. In the former case the soil invariably contained more water and organic matter than in the latter and the unhealthy seedlings invariably showed more or less extensive rotting of the roots. That the injurious agent is here a soil factor and not deficient light is clearly shown by the fact that if pots containing sand are placed in the shade of the forest, healthy seedlings with well-developed roots can be produced in them without difficulty. Plate XXVII, fig. 2 shows the development of *sal* seedlings in a cleared patch 60 ft. in diameter, and figure 1 of the same Plate shows the corresponding development in the shade of the adjacent forest. In both cases the seedlings are two years old.[1]

In all the experiments noted above, both in the pot cultures and in the forest, the symptoms shown by the unhealthy seedlings are the same. The first sign of disease is seen in the blackening and death of the tender root-tips and rootlets, the damage then spreading, unless the conditions are ameliorated, until the entire root system becomes black and rotten. It is significant that above ground the seedlings may appear quite healthy with green leaves when a number of the deeper roots are dead and rotten. This appears clearly to indicate that the injurious agent is a soil factor and the symptoms convey the impression of a localized poisonous action rather than of a general starvation effect due to lack of essential food materials. Above ground the first sign of trouble is seen in the leaves turning pale and hanging vertically downwards instead of remaining horizontally extended. Plate XXVI, fig. 2 shows healthy seedlings in the two pots on the left and in two pots on the right those showing the

[1] *Indian Forest Records*, vol. 4, part II (1916).

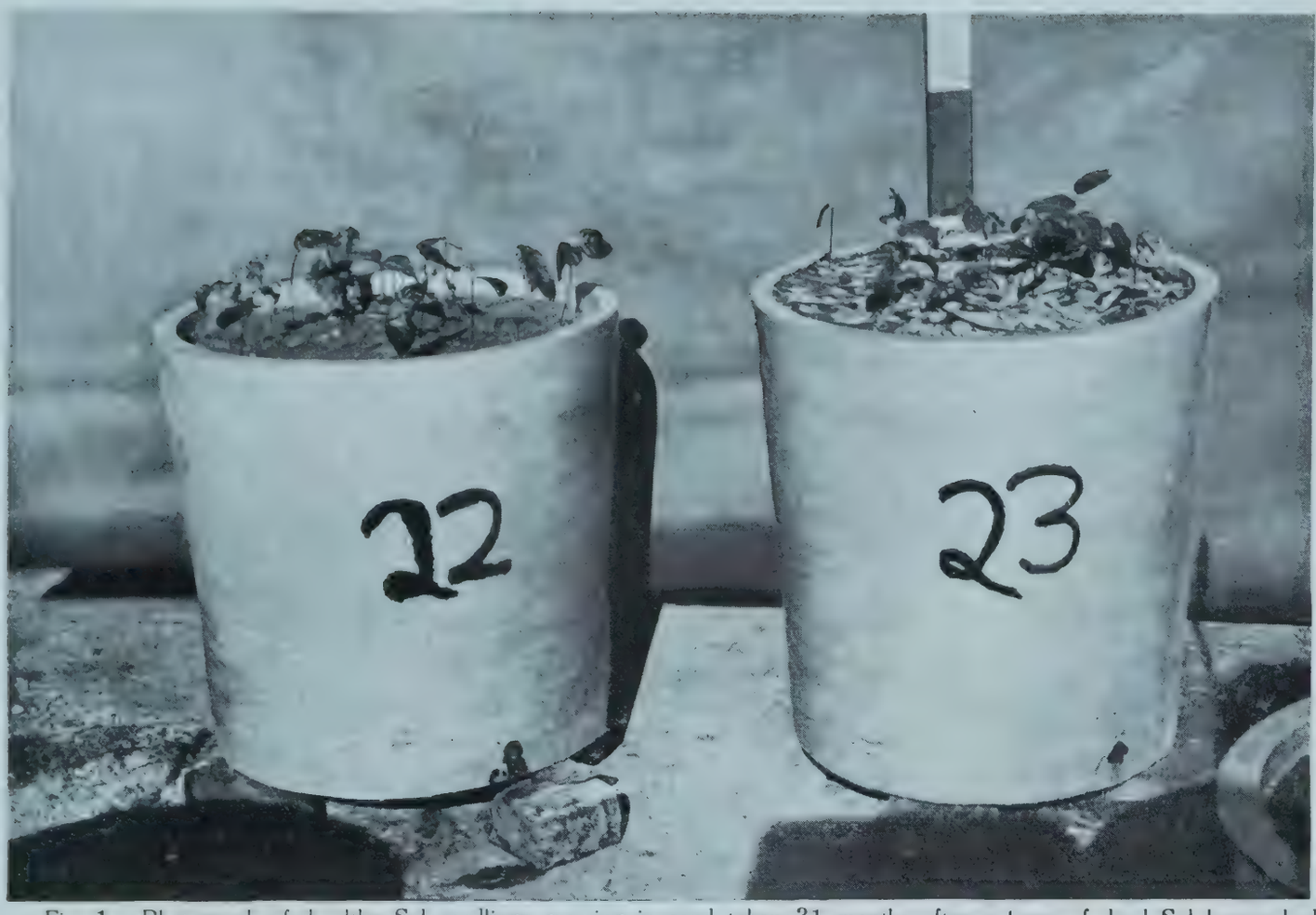


Fig. 1. Photograph of healthy Sal seedlings growing in sand taken $3\frac{1}{2}$ months after a layer of dead Sal leaves had been placed on the surface of the soil in pot 23. No dead leaves were added to pot 22. No injurious effect has been produced by the dead leaves.

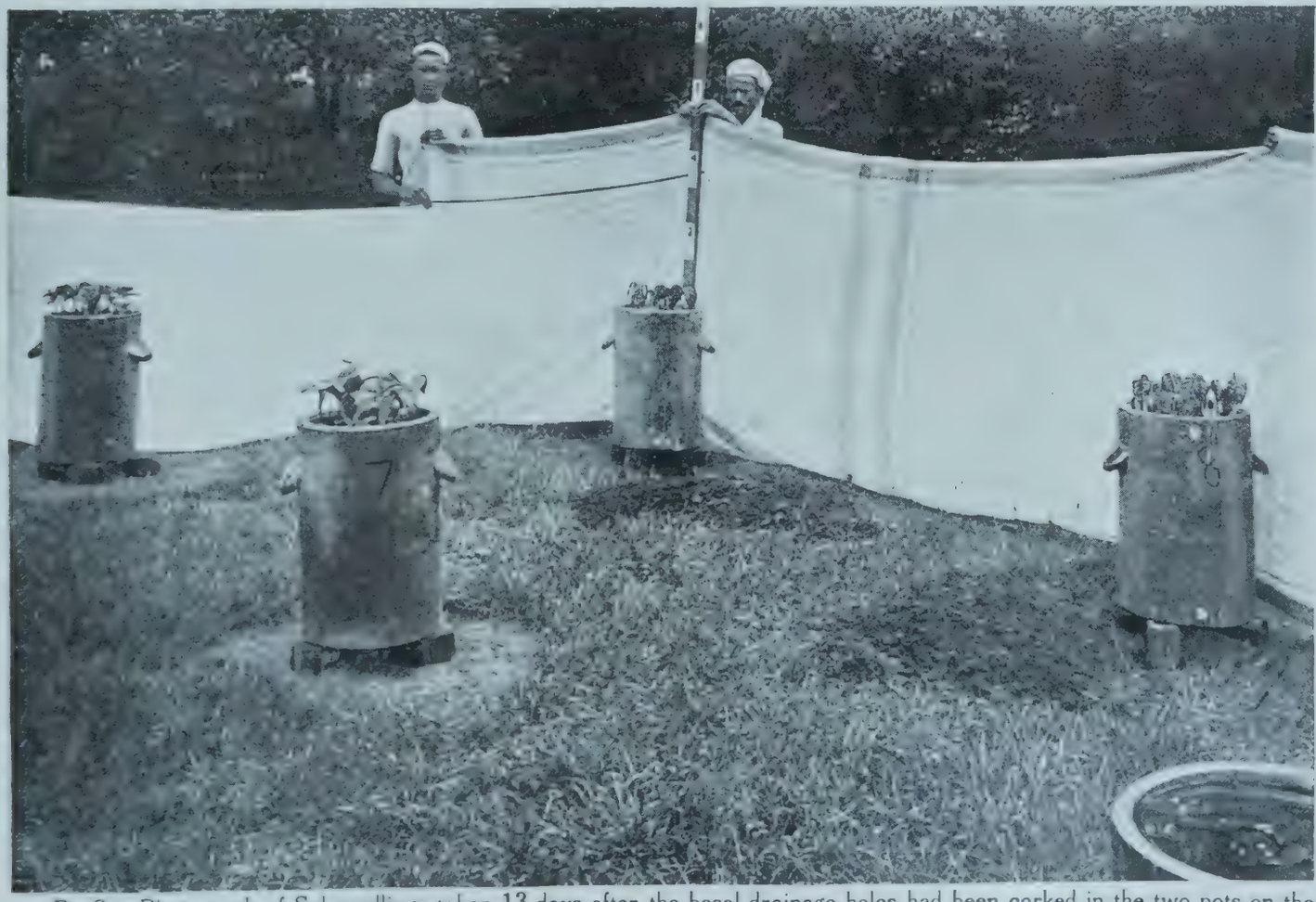
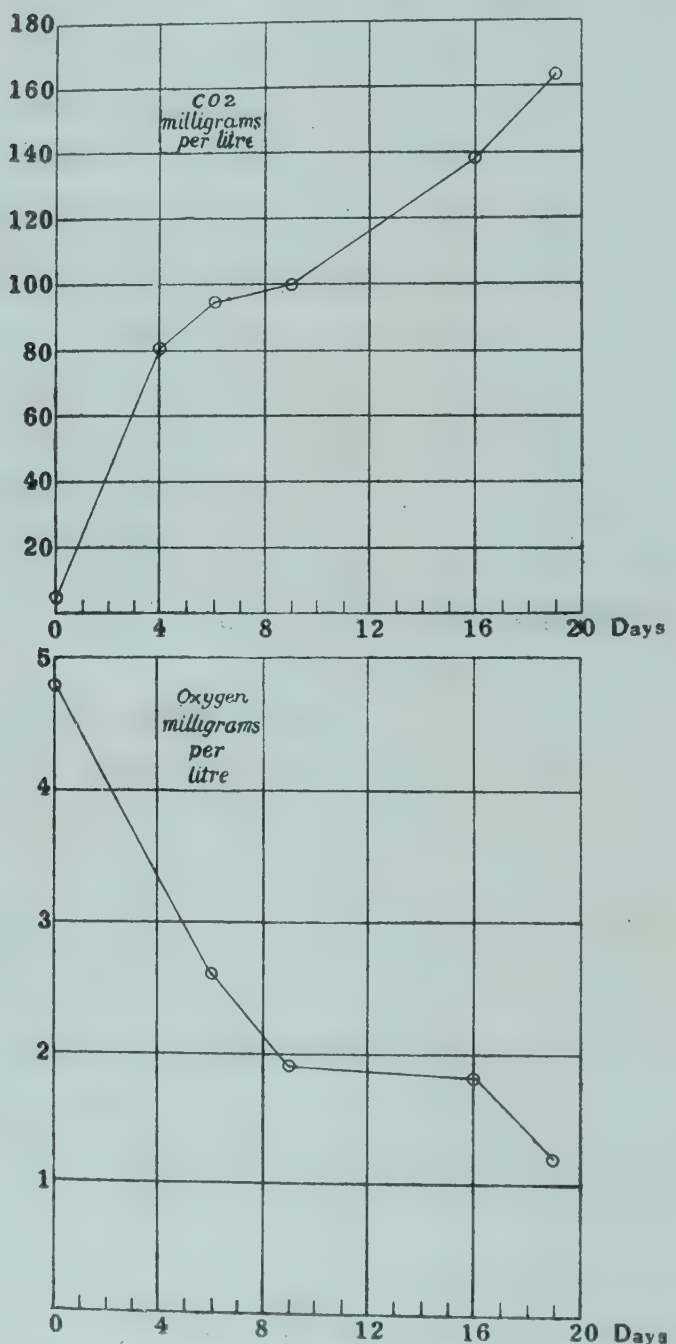


Fig 2. Photograph of Sal seedlings taken 13 days after the basal drainage holes had been corked in the two pots on the right. In these pots the seedlings are showing the first signs of trouble from bad soil-aeration, the leaves hanging vertically downwards. In the two pots on the left which were not corked the seedlings are healthy with leaves horizontally extended.

first signs of trouble from bad soil-aeration 13 days after the pots had been corked. The leaves eventually turn brown and drop off. Organisms such as bacteria and fungi are usually absent from the diseased roots at first but may invade the damaged tissue later. It must be noted that the injurious factor may and indeed usually does cause severe damage in a soil which, although being moist, is still far from being in the condition usually associated with the term "waterlogged." Experiment has shown that 100 per cent. of *sal* seedlings may be killed or seriously damaged by this factor when no water is standing on the surface of the soil and when there is a considerable water-free air-space near the roots. Again, although a moist condition of the soil undoubtedly increases the injurious action, it can be easily shown by water-culture experiments that water in itself cannot be the injurious factor. In Plate XXVIII, fig. 1 are seen *sal* seedlings which have been growing in a water-culture solution for four months and which show a vigorous development of healthy roots especially near the apex. As a general rule no difficulty is experienced in growing healthy seedlings in this way when air is allowed access to the culture solutions.

In 1915 an experiment carried out at Dehra Dun showed that when water was held in contact with the *sal*-forest loam mentioned above in glazed non-porous pots it became heavily charged with CO_2 and impoverished as regards its supply of dissolved oxygen. In 1916 a further experiment showed that when rain water, with an initial content of 1 milligram CO_2 and 7 milligrams oxygen per litre, was held in contact with this soil in glazed non-porous pots which were placed in full sunlight in the open, the CO_2 rose to from 60 to 70 milligrams in two days while the oxygen fell to 1 milligram. After 28 days the CO_2 rose to 230 milligrams. These changes took place in soil in which no plants were growing and were therefore apparently due chiefly to the activity of the living organisms in the soil. The diagram given below indicates the changes in the dissolved gases observed in rain water which was kept in contact with this soil for 19 days in corked glazed pots which were placed in the shade and in which *sal* seedlings were growing. In this case, the water added to the pots had an initial content of

4·8 milligrams oxygen and 5 milligrams CO_2 and the diagram shows that in 19 days the CO_2 had risen to 163 milligrams, this increase being correlated with a fall in the oxygen content which, at the end of the period, was 1·2 milligrams per litre. At the close of this period, in 95 per cent. of the *sal* seedlings growing in these pots the roots were completely dead and rotten.



In rain 5 mg. CO_2

After 4 days in soil 81 mg.
„ 6 „ „ 95 „
„ 9 „ „ 100 „
„ 16 „ „ 138 „
„ 19 „ „ 163 „

In rain 4·8 mg. Oxygen

After 6 days in soil 2·6 mg.
„ 9 „ „ 1·9 „
„ 16 „ „ 1·8 „
„ 19 „ „ 1·2 „

Diagram showing changes in the dissolved gases found in rain water which was held in contact with *sal*-forest loam for 19 days in corked pots.

All the figures quoted above represent the quantities of these gases which were found dissolved in the percolation water drawn off from the base of the pots.

Fig. 1

Forest shade plot V. Photograph taken 20th July, 1915. Note the appearance of the 2-years-old seedlings surviving in the plot.

Fig. 2.

Forest plot IV. An area 60 ft. in diameter was here clear-felled in May, 1913. The photograph was taken on 20th July, 1915. Note the vigorous 2-years-old seedlings surviving in the plot.

So far as our experiments, therefore, have gone at present they show that the injurious action on the roots of *sal* seedlings is associated with a very small oxygen and high carbon dioxide supply. That a deficiency of oxygen may be injurious to roots is usually accepted by physiologists and is indicated by such water-culture experiments as the one quoted by Mr. Howard. The effect of this factor on the roots of *sal* seedlings still requires to be investigated.

The effect of various quantities of CO_2 gas on these roots, however, has been tested by us, simultaneously with the pot experiments mentioned above, by growing the seedlings in water-cultures and bubbling the gas through the culture solutions.

So far as these water-culture experiments have gone at present they show that, when the concentration of the gas reaches roughly 500 milligrams per litre and above, the delicate root-tips and rootlets of vigorous *sal* seedlings are blackened and killed and the production of new roots is inhibited, the appearance of the damaged roots resembling that of those found in badly-aerated soil. Plate XXVIII, fig. 2 shows the root system of two *sal* seedlings which have been grown in water-culture for 19 days. The one on the right is healthy and was grown in an aerated solution while the one on the left has been gassed for two minutes daily, the concentration finally attained being 600 milligrams CO_2 per litre of water. The fact that the concentration required to produce this injurious effect in water-cultures is considerably higher than that which exists in the percolation water taken from pots in which *sal* seedlings are suffering severely from the injurious factor would appear, at first sight, to put CO_2 out of court as a possible cause. It is believed, however, that this conclusion is not yet justified. During these culture experiments it was noticed that those roots which happened to be near the exit of the gas tube were blackened and killed when those further away still remained uninjured, and also that healthy roots were often produced near the upper surface of the solution which was in contact with the air and farthest removed from the gas tube mouth while the roots deeper down were obviously unhealthy. It is believed that differences in concentration of this kind are even more marked in

the soil than in water-cultures such as those dealt with above. It thus seems possible that extensive damage may be done to the roots when the concentration of CO_2 in the mass of the percolation water filling the pore-space in the soil is too weak to cause injury. It must also be remembered that in badly-aerated soil there are apparently always two injurious actions at work together, *viz.*, a deficiency of oxygen and an excess of CO_2, and it is probable that the injurious action of CO_2 depends largely on the quantity of oxygen available.[1] There is reason to believe that a deficiency of oxygen is in itself injurious to the roots while such a deficiency appears to be invariably correlated with an accumulation of CO_2 and possibly also of other poisonous substances. At present, therefore, it seems probable that the most reliable indication of the conditions of aeration in the soil will be obtained by determining the quantity of oxygen and CO_2 existing in the soil and that we may define a badly-aerated soil as one in which there is a deficiency of oxygen and an excess of CO_2.

To determine whether this is correct or not, further extensive experiments are required in which determinations of these gases should be correlated with careful observations on the root growth. In forestry it is important that we should be able to determine quickly when the conditions of soil-aeration are becoming unsuitable for the healthy development of our trees so that the treatment may be altered without undue loss of time and before serious damage has been done. Analysis of the soil gases at present promises to be the best means of effecting this, and it is with the hope that the attention of some of those eminent chemists who are present here to-day may be attracted to the subject and that they will help us to elaborate easy and practical methods of soil-gas analysis suitable for application in the forests that the present paper has been written.

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[1] Thus Kidd has shown that, with 5 per cent. oxygen, 9-12 per cent. carbon dioxide inhibits the germination of seeds, whereas, with 20 per cent. oxygen, 20-25 per cent. carbon dioxide was required to produce inhibition with a temperature of 17° C. (*Ann. Bot.*, XXXI, p. 457, 1917.)

Fig. 1. Sal seedlings which have been growing in a water-culture solution for 4 months and which show a vigorous development of healthy roots, especially near the apex.

Fig. 2. Showing the root-systems of two Sal seedlings which have been grown in water-culture for 19 days. The one on the right is healthy, showing numerous healthy young roots, and was grown in an aerated solution, while the one on the left has been gassed for 2 minutes daily, the concentration finally attained being 600 mg. CO_2. per litre of water. In this case the root is dead at the apex and there are no healthy young roots.

From what has been said above it will be seen that soil-aeration apparently depends chiefly on :

(1) The amount of water in the soil.
(2) The amount of organic matter in the soil.
(3) The number and kind of soil organisms.
(4) The rate at which currents of air, or water with oxygen in solution, penetrate into and percolate through the soil.

In the *sal*-forest loam used in the pot experiments mentioned above, bad aeration appears to depend chiefly on the first three of these factors, but experiments have shown that soil texture and rate of percolation are no less important. Plate XXIX, figs. 1 and 2 show the growth of *sal* seedlings of the same age in porous and dense loam respectively. In the latter the time required for $\frac{1}{2}''$ of water to penetrate below the surface was 750 seconds whereas in the former it was 46 seconds. Note the respective root growth of the seedlings in the two cases. In dense soil germination is reduced, more seedlings die during the rains of bad aeration and of drought during the dry season owing to poor root development.

It is important to note that the various agencies which influence soil-aeration can be controlled to a considerable extent by ordinary forest operations apart from the obvious but expensive methods of draining and soil cultivation. Thus the quantity of water, of soil organisms, and of organic matter can be regulated by varying the shade and quantity of dead leaves added to the soil and also by the controlled use of fire. Texture is also influenced by the amount of organic matter in the soil and also by such factors as the grazing of cattle, both of which are capable of regulation. In some cases the temporary encouragement of the growth of certain grasses and other herbs, the roots of which are much sought after by such forest cultivators as rats and pigs, is an important factor in improving soil texture. The felling of trees and the subsequent decay of the subterranean roots is also an important factor in influencing soil-aeration, a point which has recently been emphasized by Mr. Howard. There is thus good reason to believe that,

provided we can elaborate a method, by soil-gas analysis or otherwise, of quickly and accurately identifying a condition of bad soil-aeration, we shall, at any rate in many cases, be able to apply the necessary remedy.

As regards the general importance of soil-aeration in Indian forestry, it must I think be accepted that this factor is of primary importance in the case of the *sal*, the only species which up to date has been studied in any detail in this connection and regarding which our knowledge is still very imperfect. In the moist forests of Dehra Dun it has been shown that the establishment of seedling growth depends primarily on this factor, and Mr. R. S. Troup has recently shown that this is also the case in the moist *sal* forests of Bengal and Assam.[1] In the latter case it is interesting to note that subjecting the forest to fires is now said to be improving the seedling growth. Apart from the question of the establishment of seedlings, Mr. R. G. Marriott has recently ascribed the poor development of older trees to this factor and suggests that, owing to it, the trees may practically cease to grow during the rains which ought to be the period of most vigorous growth.[2]

Finally, it is interesting to note that, although the *sal* root fungus *Polyporus Shoreæ* is widely distributed throughout the *sal* forests of India, so far as is known at present, it only causes serious damage in those wet forests of Bengal and Assam in which the conditions of soil-aeration are known to be particularly unfavourable. Bad soil-aeration by producing a diseased and sickly condition in the roots may be a factor of great importance in facilitating the attacks of injurious root-fungi of this class. It is interesting to note from an ecological point of view that the natural distribution of the *sal* appears to be regulated largely by this factor. Thus good *sal* forests are not known to occur on really wet soils unless these soils consist chiefly of gravel and sand. On loam the best *sal* forests are limited, so far as we know at present, to those areas which are well drained and where the soil texture is good.

[1] *Note on the Forests of the Duars*, Simla, 1915, p. 36.
[2] *Indian Forester*, vol. XLIII, p. 444.

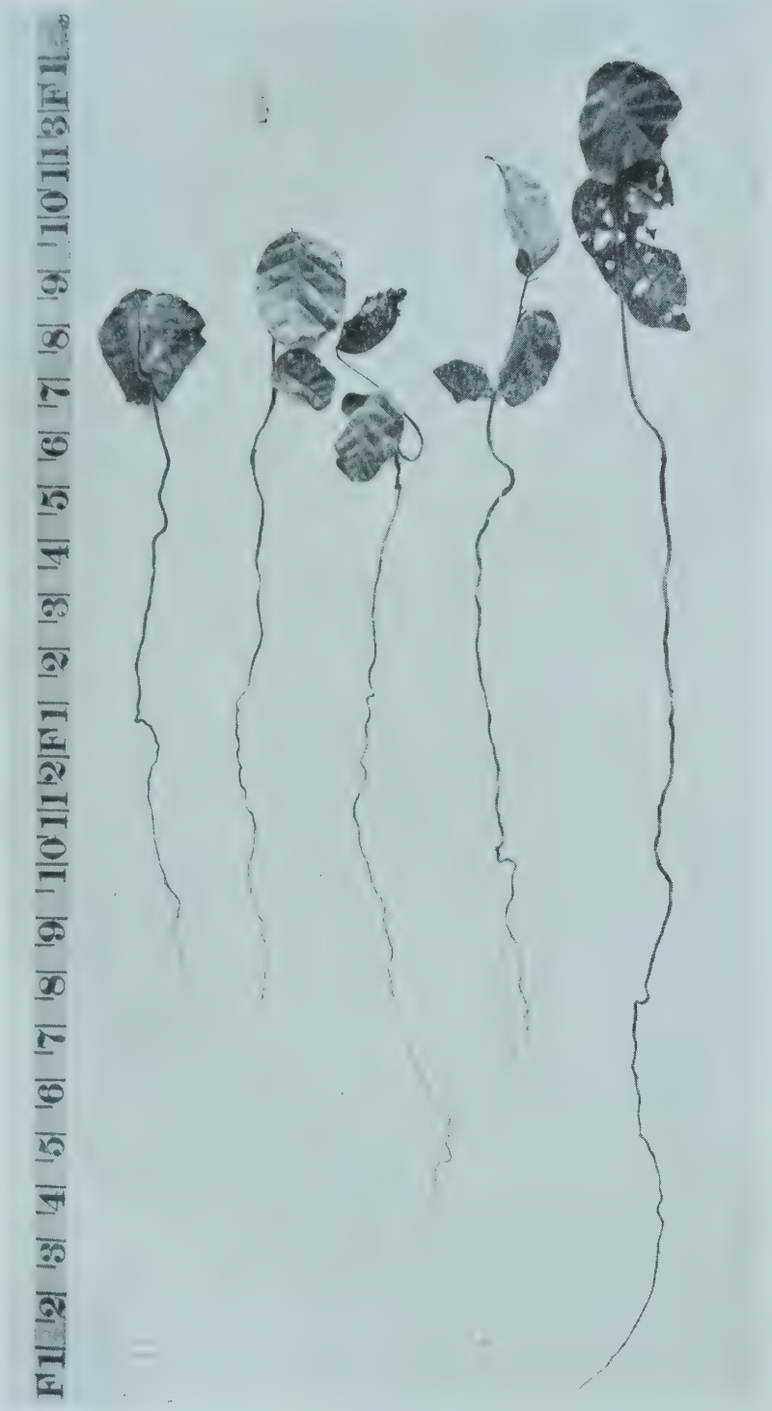

Fig. 1.

Fig. 2.

Showing the root-development of Sal seedlings at the end of the first rains; in Fig. 1, plants which have been grown in porous well-aerated loam and, in Fig. 2, plants which have been grown in dense badly aerated loam. Note the respective root-growth in the two cases.

These facts of distribution accord precisely with the results of the Dehra Dun pot experiments which have shown that whereas on well-aerated sand it is practically impossible to give too much water to *sal* seedlings, the latter are very susceptible to injury by bad soil-aeration in loam.[1]

There is good reason for believing that several other species of our most valuable Indian trees are no less susceptible than *sal* to the influence of soil-aeration, and, speaking generally, there can be little doubt that this factor is of great importance in Indian forestry whether considered with reference to its effect on the healthy growth and development of seedlings and trees or its possible connection with injurious diseases or, finally, with regard to its ecological importance in influencing the distribution of species and types of vegetation.

Before leaving this subject I venture to suggest that the following, which of recent years have attracted much attention, may possibly be found to be primarily cases of bad soil-aeration. Pickering's experiments at Woburn have demonstrated the injurious effect of grass on fruit trees, which has been attributed to the presence in the soil of a toxin which is either produced directly by the grass roots or from the organic remains of such plants. A dense growth of grass is correlated with an accumulation of dead roots, leaves, and other debris in the surface soil, which would ordinarily encourage the rapid reproduction of the soil organisms engaged in the decomposition of organic matter. We should naturally expect that rain water, percolating through such a layer of grass, would tend to be deprived of its oxygen by the numerous living grass roots and soil organisms and would become heavily charged with CO_2. Pickering notes that when such "toxic" water is exposed to the air for 24 hours its toxic property is found to have entirely disappeared.[2] Exposure to the air would tend to make good a

[1] That soil-aeration influences the distribution of types of vegetation other than *sal* forest is indicated in *Indian Forest Memoirs*, Bot., vol. I, 1, p, 46 (1911) and in *Indian Forester*, XLII, p. 344 (1916.)

[2] *Annals of Botany*, 31, p. 184, (1917).

deficiency of oxygen and to dissipate an accumulation of CO_2 by diffusion.[1]

The work of Russell and others at Rothamsted has shown that in soils which are kept moist, warm, and richly supplied with organic matter plant growth is frequently unsatisfactory and this is correlated with an exceptional development of the larger soil organisms such as protozoa. May not this unusual development of large organisms be responsible for a deficiency of oxygen and an accumulation of carbon dioxide, and thus for a condition of bad soil-aeration ?

In conclusion, although I have enjoyed the privilege of putting these points before the members of the Science Congress, it must not be thought that I, personally, can claim the credit for such results as have already been obtained. For the recognition of the importance of soil-aeration in practical forestry we are indebted to the careful observations of forest officers like Messrs. R. S. Troup and R. G. Marriott, while as regards the experimental work carried out at Dehra Dun the lion's share, including all the chemical work, has been done by Mr. Puran Singh, our Chemical Adviser, and his assistant, Mr. T. P. Ghose, who have carried this through under great difficulties and under constant heavy pressure from other duties.

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[1] Mr. Howard made a similar suggestion in 1915, *see* "Soil Ventilation," *Pusa Agr. Res. Inst. Bulletin No. 52*, pp. 22, 23.

PRESENT POSITION AND FUTURE PROSPECTS OF THE NATURAL INDIGO INDUSTRY.

BY

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III. THE FUTURE OF NATURAL INDIGO IN INDIA.

HAVING in the preceding article (*Agricultural Journal of India*, vol. XIII, page 206) described the existing methods of indigo culture and manufacture, I will now consider the possibility of effecting improvements in these. It is clear that very great improvements *can* be made and after two years' study of the question I have formed the opinion that the future of natural indigo is by no means a hopeless one provided steps are taken to realize such improvements as are clearly possible. The fate of natural indigo will be determined by several factors, each of which has its own special importance :—

(*a*) Improvements in agriculture.

(*b*) Improvements in actual manufacture, either by chemical or bacterial means.

(*c*) Improvements by botanical selection.

(*d*) Improvements in methods of marketing the product.

(*e*) Improvements in business organization.

I will now deal with these different questions in turn.

(*a*) IMPROVEMENTS IN AGRICULTURE.

The agricultural side of the problem is to my mind the most serious one in Bihar at the moment and the one needing most immediate attention. On the other hand, it is on this side that,

from the evidence now available, most immediate improvement seems possible. Such improvement must however necessarily be gradual and a matter of time. Whether natural indigo can hold its own in the future against the competition of synthetic, is mainly a question of cost of production. If the cost of each pound of natural indigo can be lowered so as to enable it to compete with synthetic in price, providing the natural indigo be put on the market in the same convenient and standardized form as the synthetic, there is every reason to believe that it will be able to hold its own against the synthetic dye. The dominant factor is undoubtedly the price per unit of indigotin.

The *possibilities* of natural indigo are best made clear by the following considerations. High-quality Java indigo leaf contains 0·7 to 0·8 per cent. of indigotin[1] at the time when it is ripe for cutting. Now a yield of 100 to 120 maunds of green plant per acre can be obtained *on lands in good condition*, and the plant will contain about 50 per cent. by weight of leaf. The following table gives the theoretical yields in seers of 60 per cent. indigo per 100 maunds of plant for different percentages of leaf or plant and for different percentages of indigotin in the leaf:—

TABLE I.

Theoretical yields of 60 *per cent. indigo per* 100 *maunds of plant.*

Per cent. of leaf on plant	YIELD IN SEERS OF 60% INDIGO WHEN THE LEAF CONTAINS			
	1·0%	0·8%	0·6%	0·5% indigotin
40	26·70	21·4	16·0	13·35
50	33·33	26·7	20·0	16·66
60	40·00	32·0	24·0	20·00

The numbers of this table also give the yield in seers of 60 per cent. indigo *per acre* if each acre be assumed to yield 100 maunds of plant; if the yield of plant per acre be as high as 120 maunds

[1] Rawson's analyses of Java indigo leaf (see *Report to Bihar Planters' Association*, 2nd Edn. 1907) in several instances showed 0·9 and even 1 per cent. of indigotin. Nearly 1,000

(and in some of the better soils of Bihar at the present time the yield is actually greater than this) the following table gives the result: –

TABLE II.

Theoretical yield of 60 *per cent. indigo on the assumption that each acre yields* 120 *maunds of green plant.*

Per cent. of leaf on plant	YIELD IN SEERS OF 60% INDIGO WHEN THE LEAF CONTAINS			
	1·0%	0·8%	0·6%	0·5% indigotin
40	32·0	25·7	19·2	16·0
50	40·0	32·0	24·0	20·0
60	48·0	38·4	28·8	24·0

These figures are useful in forming an idea of the possibility of natural indigo competing in price with synthetic in the future. Provided that the agriculture be improved so that the yield of green plant be brought up to the level of, say, 120 maunds per acre and the methods of manufacture improved so that the whole of the dye stuff of the plant be extracted, we will now show that the natural dye should be able to compete very favourably with the synthetic article.

The German price for synthetic before the war in the United Kingdom was 8*d.* per lb. for 20 per cent. paste,[1] which would be

analyses made by Parnell (*Report of Sirsiah Station*, 1913) showed extraordinary variations in individual plants, the following table summarizing the results :—

Year			No. of analyses	Average	Highest	Lowest
1910	...	...	200	0·54	0·76	0·35
1911	...	...	353	0·61	0·92	0·37
1912	...	...	336	0·50	0·78	0·32

The content of indigotin apparently increases in the leaf up to a maximum which is reached somewhere about the time of cutting. There is no doubt too that the ordinary Java plant now grown in Bihar is a mixture of a large number of different varieties (many differences are obvious merely to the eye) and Parnell's work shows that these varieties differ widely in indigotin content.

It should be noted that both Parnell and Rawson analysed their plant by the persulphate method. From a large number of comparative analyses made by the writer last season this method apparently gives results which are at least 20 per cent. lower than the more correct values obtained by the isatin method. It is therefore a conservative estimate to assume that *good* quality Java plant contains 0·7 to 0·8 per cent. of indigotin.

[1] See *Proceedings of the Conference on Natural Indigo held at India Office*, September 20, 1915.

equivalent to 60 per cent. natural indigo at 2*s.* per lb. or Rs. 112 per maund of 74·66 lb. As regards the actual cost of production of natural indigo, planters' opinions differ, but Mr. D. J. Reid, one of the most successful planters, stated at the Delhi Conference[1] that with a yield of 35 seers to the acre, natural indigo could be produced at Rs. 40 a maund. Mr. G. R. MacDonald hesitated to accept this figure and "taking bad years into account, doubted whether the average cost of production would be less than Rs. 80 a maund." It should be pointed out here that Mr. Reid's estimate is based on the assumption of a *steady* output of 35 seers, whereas Mr. Macdonald's takes into account *bad years* in which the crop would give considerable lower returns. Mr. Bernard Coventry, C.I.E., late Agricultural Adviser to the Government of India, has recently expressed the view that if at his factory (Dalsing Sarai) "we could only grow the plant properly, it would give us at least 20 seers a bigha and with such a yield I would undertake to undersell synthetic indigo at practically any price." Mr. Reid, it should be pointed out, has since 1905 been one of the largest growers of the Java plant—in the year 1911 and 1912 for example, he had nearly 2,500 bighas under Java indigo[2].

Table II given above shows that with Java indigo plant containing 0·8 per cent. of indigotin in the leaf and yielding 120 maunds of plant, 50 per cent. of which is leaf, to the acre, the theoretical yield of 60 per cent. indigo is 32 seers. If the quality of the leaf were increased by careful selection (and the writer regards this is quite possible in view of Parnell's early experiments at Sirsiah, carried out under most disadvantageous conditions) so that the average amount of indigotin in the leaf were 1 per cent., so high a theoretical yield as 40 seers of 60 per cent. indigo would be possible. If by suitable selection the proportion of leaf to stick in the plant were at the same time increased, so that it contained 60 per cent. of leaf containing 1 per cent. of indigotin, the theoretical yield would reach the enormously high value of 48 seers to the acre.

[1] *Proceedings of the Conference on Indigo held at Delhi*, February 22, 1915.

[2] See his article "Ten years' practical experience of Java Indigo in Bihar," *Agricultural Journal of India*, vol. XII, part I, January 1917.

The deterioration of Bihar indigo soils and the necessity of proper manuring.

In the writer's opinion the most important immediate factor in the indigo problem is that the deterioration of Bihar soils, which has followed neglect of proper manuring in the past, should be remedied. On the promptitude of the adoption of remedial measures will largely depend the possibility of natural indigo being produced in Bihar at a sufficiently low price to compete with the synthetic article in the immediate future.

In a special pamphlet[1] recently circulated to Bihar Planters, the writer has dealt at considerable length with the evidence which shows that during the past 20 years the indigo soils of Bihar have been rapidly stripped of fertility owing to the using up of the small reserves of available phosphate. It has been pointed out that unless proper manuring with superphosphate is *immediately* adopted, there is every indication that during the next few years the yield of indigo per acre will fall off throughout Bihar in an alarming manner and that it will then become absolutely impossible for natural indigo to compete with the synthetic dye—the final extinction of natural indigo will then be certain.

The indications of deterioration of the soils of recent years are numerous. Not only is such deterioration clear from actual analysis of the soils but wherever proper trials with superphosphate as a manure have already been made, the response has been remarkable, showing that the deficiency in phosphate has been the principal trouble.

When the Java plant was first introduced into Bihar and the early difficulties in the way of its cultivation had been overcome, the returns from this plant were so remarkable that it was confidently expected that its general adoption would save the indigo industry. In many cases the produce of indigo per bigha was from three to four times that given by the old Sumatrana plant—two and even three heavy cuttings of leaf were obtainable. The

[1] Indigo Publication, No. 1, *A Study of the Indigo Soils of Bihar*, pp. 75 (1918), by W. A. Davis.

data given by Mr. D. J. Reid in his article "Ten years' practical experience of Java indigo in Bihar" are very instructive. In the year 1906 to 1907 we have the following comparisons :—

TABLE III.

Belsand Head Factory, Season 1906-1907.

JAVA INDIGO							SUMATRANA INDIGO				
Cuttings	Bighas	Indigo			Produce per bigha		Cuttings	Bighas	Indigo		Produce per bigha
		Mds.	Srs.	Ch.	Srs.	Chtks.			Mds.	Srs.	Srs. Chtks.
1st	666	172	31	8	10	6	1st	712	73	10	4 2
2nd	645	160	23	12	9	15	2nd	171	4	10	1 0
3rd	303	21	14	4	2	13	.....	.....	....	.	.....
	Total ...	354	29	8	23	2		Total ...	77	20	5 2

Bhagwanpur Factory, Season 1906-1907.

JAVA INDIGO						SUMATRANA INDIGO			
Cuttings	Bighas	Indigo		Cake produce per bigha		Cuttings	Bighas	Indigo	Cake produce per bigha
		Mds.	Srs.	Srs.	Chtks.			Mds.	Srs. Chtks.
1st	133	42	18	12	12	1st	670	99	6 0
2nd	117½	44	16	15	2	2nd	230	24	4 2½
3rd	53	11	14	8	9	.....	.....	.....	.....
	Total ...	98	8	36	7		Total ...	123	10 2½

At Belsand Factory the yield of indigo per bigha (which is the principal thing for the planter) was more than four times as great with Java indigo as with Sumatrana; at Bhagwanpur it was slightly less than four times. The yield of cake produce per bigha reached the remarkably high figure at Bhagwanpur of 36 seers 7 chattaks (*i.e.*, 41½ seers per acre) whilst at Belsand it was 23 seers 2 chattaks (*i.e.*, 27 seers per acre). In fact, the value obtained at Bhagwanpur actually exceeded the value of 32 seers per acre corresponding (according to Table II) with the theoretical yield of 60 per cent. indigo from 120 maunds of green plant to the acre, with a leaf percentage of 50 and an indigotin content of 0·8 per cent.; it even

exceeded that possible with plant containing 60 per cent. of leaf with the other factors the same. At Belsand (where it will be shown the soil is inferior to that of Bhagwanpur) the yield per bigha was somewhat lower, but still so high as 23 seers.

The significance of the above results lies in their clearly demonstrating the *possibility* in actual estate practice of obtaining very high yields of indigo per acre from the Java plant, when the soil conditions are favourable. With such yields as 35 seers to the acre, Mr. Reid (*see* page 444) has calculated that natural indigo could be produced at Rs. 40 per maund, which is far below the actual pre-war selling price of synthetic indigo (Rs. 112). With such a yield it should be an easy matter for natural indigo to compete with and hold its own against the synthetic product. Even with the considerably lower yields obtained at Belsand (23 seers per bigha) there should be no difficulty.

Unfortunately the promise which the Java plant first held out was not long maintained. For two or three years phenomenal results were obtained at many factories; the plant grew magnificently, required little trouble in cultivation, and in several cases the plant was carried on from season to season without re-sowing. But in the year 1907 trouble began to be experienced: two diseases appeared simultaneously in Bihar, the one due to an insect pest "Psylla," and the other the far more destructive "wilt" disease. Owing to the latter disease, which led to the partial or complete dying out of *khoonties* or the failure of seed plant, it gradually became impossible to obtain sufficient seed for general use and the output of indigo rapidly fell off. In 1911 the General Secretary of the Bihar Planters' Association wrote to the Inspector-General of Agriculture: "The disease this season totally destroyed the *khoontie* crop of Bihar and had there been no disease at least 10,000 maunds more indigo could have been made, valued at Rs. 15,00,000 or £100,000 sterling. The condition of affairs is most serious and, what is of the greatest importance, the plant that has been kept for seed gives practically no return."

Since 1911 the *khoontie* plant throughout Bihar has died out partially or completely each year. Many estates now invariably

fail to give *khoonties* at all and on the majority it is impossible to obtain seed from the Java plant. At first it was thought that the "wilt" might be a fungal or bacterial disease but Dr. E. J. Butler at Pusa could find no evidence in support of the former view nor Mr. C. M. Hutchinson of the latter. **The writer considers that the disease is entirely due to phosphate starvation** owing to soil deterioration caused by continual cropping and has recently published a large number of analyses and facts in support of this view[1]. It is not necessary here to go into the evidence in detail, but I will briefly deal with the question from a general point of view.

In the first place, there is strong evidence to show that during the past 20 years the soils have undergone considerable deterioration as regards the amount of available phosphate present. In practically all cases where analyses have been recently made, the soils have been found to be singularly deficient in "available phosphate." In most cases the amount is far below the 0·01 per cent. generally regarded as necessary for fertility. A large number of Bihar indigo soils contain less than 0·0002 per cent., whilst in several only the merest traces can be detected.

Actual factory data indicate in several cases that the deterioration of yield from the Java plant has been progressive, and has taken place over a series of years. For example, if we examine Table IV which shows the yields from 1905-1912 at Belsand and Bhagwanpur factories, the gradual and continuous falling off of yields is—making allowances for slight seasonal variations—quite apparent.

The first symptom of deterioration in the soil at Belsand was the gradual failure of seed yield, generally the first indication of phosphate starvation. When the Java plant was first grown at Belsand it gave very high yields of seed—15 maunds to the acre in 1904-1905. Next year the yield of seed fell to 9 maunds and in 1906-1907 the yield is described (*see* D. J. Reid's article) as "disappointing." Up to this time, 1906-1907, the green plant had given astonishing yields—even after the seed began to fall off the cuttings of leaf plant were very good. In the seasons 1906-1907 and 1907-1908 three cuttings of leaf were taken, the total yield per bigha

[1] *Indigo Publication*, No. 1.

Year	BELSAND							BHAGWANPUR						
	1st cut per bigha, seers	2nd cut per bigha, seers	3rd cut, seers	Total average per bigha, seers	Area cut, bighas	Total make, mds.	Remarks	1st cut per bigha, seers	2nd cut per bigha, seers	3rd cut, seers	Total average per bigha, seers	Area cut, bighas	Total make, mds.	Remarks
1905–1906	9–7½	.....	...	.....	289	68	Plant over-matured when put in vats.	.....	.....	...	.....	.....	...	.....
1906–1907	10 6	9 15	2 13	23–2	1st cut 666 2nd ,, 645 3rd ,, 303	355	No wilt.	12–12	15 2	8 9	36 7	1st cut 123 2nd ,, 117½ 3rd ,, 53	98	No wilt.
1907–1908	8–10	9 9½	5–4	23–7½	1st ,, 1,334 2nd ,, 1,191 3rd ,, 233	605	No wilt.	12–2	9–11	...	21–13	1st ,, 908 2nd ,, 614	423½	All 2nd cuttings could not be utilized owing to dam impeding water for manufacture. No wilt.
1908–1909	5–0	1–0	...	6–0	1st ,, 1,559 2nd ,, 269	203	Wilt appeared in *khoonties*, plant largely damaged by hail in May.	6–0	2–2½	...	8–2½	1st ,, 945 2nd ,, ...	146	No wilt. Plant damaged by hail-storm in May.
1909–1910	7–1	6–7	...	13–8	1st ,, 1,606 2nd ,, 507	366	*Khoonties* largely lost by flood.	8–7½	5–2	...	13–9½	1st ,, 1,137 2nd ,, 242	272½	No wilt.
1910–1911	7 3	2–15	...	10–2	1st ,, 1,533 2nd ,, 385	299	*Khoonties* badly attacked by wilt.	8–4½	8–12½	...	17–1	1st ,, 1,132 2nd ,, 877	428	No wilt.
1911–1912	4–14	2–1	...	6–15	1st ,, 1,470 2nd ,, 778	220	Worst season* recorded for wilt of *khoonties*.†	6–3	3–3	...	9–6	1st ,, 925 2nd ,, 746	203	No wilt this year.

Seed yield "*Belsand*" ... 1904—05 .. 15 mds. per acre (uncut plant).
1905—06 ... 9 ,, ,, ,, ,, ,,
1906—07 ... "Yield disappointing" ,,
1907—08 ... No uncut plant retained: seed from once cut plant, fair.
1908—09 ... First year in which wilt affected yield of green plant.

* After this year owing to bad returns, cultivation of indigo greatly reduced.

† Return per bigha from the *first* cutting was also very poor. Not only was this so but "the yield of indigo per 100 mds. of plant was considerably lower this season than in others," showing an actual deterioration in quality.

at Belsand in the former season being 23 seers 2 chattaks of cake indigo per bigha and 36 seers 7 chattaks per bigha at Bhagwanpur. After 1908 the yield of green plant and leaf rapidly began to fall off (the year 1908-1909 should be omitted from consideration, because in this year a heavy hail-storm in May seriously damaged the whole crop and the abnormally low results are due to this cause). The main falling off at Belsand was due to the development of wilt in the *khoonties*: the following are the values (omitting the year 1908-1909) :—

	Khoonties Seers	Chattaks	
1907-1908	14	13½	(includes 3rd cut).
1908-1909	.....		
1909-1910	6	7	
1910-1911	2	15	
1911-1912	2	1	

But even the *first* cuttings were affected and showed a considerable and increasing failure, especially after 1910-1911.

Season	First cutting indigo per bigha Seers	Chattaks
1906-1907	10	6
1907-1908	8	10
1909-1910	7	1
1910-1911	7	3
1911-1912	4	14

The *quality* of the first cuttings also deteriorated in a marked way, the yield of indigo per 100 maunds of green plant diminishing considerably (*see* note to Table IV).

At Bhagwanpur a similar falling off of the yield is seen, although up to 1911-1912 *no actual wilt appeared at this factory*: here again the deterioration is most marked in the *khoonties* :—

	Yield of indigo per bigha—*khoonties* Seers	Chattaks	
1906-1907	23	11	
1907-1908	9	11	
1909-1910	5	2	(*khoonties* partly lost by flood).
1910-1911	8	12½	
1911-1912	3	3	

The Bhagwanpur soil was in 1906-1907 considerably better than the Belsand soil—hence the surprising yield at this factory of 36 seers 7 chattaks of cake indigo per bigha. The superiority of the soil also appears in the fact that no actual wilt developed at

Bhagwanpur up to 1911-1912, whilst on the adjacent Belsand estate wilt appeared in the *khoonties* in 1908-1909. But that the soil was rapidly deteriorating is clear from the falling off of produce especially from *khoonties*.

The position at the present time.

During the past few years the failure of *khoonties* (second cuttings) has become more and more general each year throughout Bihar—in 1917, *khoonties* failed on many estates where formerly moderate crops were obtained. The actual falling off of the crops in the past two years is seen from the following figures taken from the Indigo Memorandum of the Department of Statistics :—

Year	Area in acres	Yield of indigo
1916-1917	76,500	10,800
1917-1918	85,900	10,300

Thus although the area under indigo was increased in 1917-1918 by 12 per cent. the total produce fell off by nearly 5 per cent., that is, an actual loss in the past year of 17 per cent. If we consider the falling off at individual factories due to the failure of plant the position becomes even more alarming : thus at Belsand—

In 1907-1908, Total produce of cake indigo—604 mds. 27 srs. from 1,334 bighas cultivation.
In 1911-1912, Total produce of cake indigo—220 mds. 7 srs. from 1,470 bighas cultivation.

In both years the *climatic* conditions were very favourable and there was little loss from flooding : *yet the produce fell off in this interval by two-thirds.*

At the present time from returns which have been sent me it appears that the average produce of cake indigo in Bihar is for Sumatrana plant 6 to 7 seers per acre and for Java plant 10 to 12 seers per acre. The yield of *green* plant per acre (as well as the yield of indigo per 100 maunds of plant) is exceedingly variable ranging

for *Sumatrana* plant from 31 mds. (minimum) to 119 mds. (maximum) ;
„ *Java* plant „ 63 „ „ „ 105 „ „

In some cases the yield of green plant per acre from Java indigo has been even less than from Sumatrana owing to the greater loss of *khoonties* by dying out (wilt).

Even with Java plant the yield of indigo is often now only 6 to 7 seers a bigha. Thus at Belsand Table IV shows that land which in 1906-1907 yielded 23 seers of indigo, in 1911-1912 only gave 6 seers per bigha ; at Bhagwanpur where in 1906-1907 the yield was 36 seers to the bigha the yield had fallen to 9 seers in 1911-1912.

Is it possible to bring about a return to the former high yields of indigo ?

There is no doubt that when the *soil conditions* are satisfactory extraordinary yields of indigo per acre *can* be obtained. This is clear from the Bhagwanpur and Belsand figures ; **the Bhagwanpur soil gave, when the Java plant was first grown, the extraordinary return of 41½ seers of Indigo per acre.** The vital question is whether it is possible so to improve the Bihar soils in general by simple methods as to increase the yield of indigo to a value of 20 to 30 seers per acre, a yield which would enable natural indigo easily to compete with the synthetic and pay handsome profits.

In my opinion, from the evidence already available, such improvement is clearly possible—the way lies in continuous and systematic manuring with a readily available phosphatic manure—superphosphate. During the past 100 years the indigo soils have been systematically depleted by the continual growth of indigo, until they have been brought to a condition of absolute starvation.

That the main factor has not been a degeneration of the indigo plant—although *some* deterioration may have occurred—is clear from the fact that when ordinary Bihar seed is now grown *in good soils outside Bihar* the same surprising returns are obtained as were given when the Java plant was first introduced into Bihar. Thus for example at Kot-Chandpur (Bengal) on a soil containing 0·374 per cent. of available phosphate (that is nearly 750 times the amount present in many Bihar soils to-day—those with 0·0005 per cent.) the yield of Java indigo seed obtained last year was 20 maunds per acre. At Jorhat, Assam, with a rainfall of 90″—far higher than in Bihar, so that the fields are frequently waterlogged—the plant grows most luxuriantly. Whereas the indigo plant in Bihar is now on most estates a poor stunted shrub seldom more than

3 to 4 feet high, at Jorhat (available phosphate 0·074 per cent.) it grows most luxuriantly. Mr. Tunstall recently informed me that the Java plants attain a height of 12 to 15 feet, the stem is 1″ to 1½″ in diameter, and the plants yield seed heavily and continuously for several months. At Jalpaiguri (Bengal), with an *annual rainfall of* 150 *inches*, luxuriant plant 12 feet high was obtained—again on a soil very rich in available phosphate (0·0978 per cent.). Climatic conditions, in fact, as shown by Mr. Reid in his article, "have little if anything to do with wilt."

It is in fact a question of some importance—whether it would not be a profitable speculation to take up the manufacture of indigo grown on rich soils outside Bihar, such as those of Jorhat and Jalpaiguri. From such soils, the yields of indigo should be of the order obtained in Bihar when the Java plant was first introduced—25 to 35 seers per acre—a yield which would give handsome profits even at pre-war prices.

That the Bihar soils are capable of very great improvement by proper manuring with phosphates[1] is clear in the few cases where experiments have been systematically made. I have given details of these in my Indigo Publication No. 1 and a former paper in this Journal.[2] I have also, in the Indigo Publication referred to, shown that although the present price of superphosphate is high the increased returns even in the first year will generally more than cover the cost of the manuring. The late Mr. Francis Coventry in February of last year reported to me the results of experiments he had carried out with superphosphate as follows :—

"*The application of* 3 *to* 4 *cwt. of* 22 *per cent. superphosphate per acre on good quality lands but that have not been manured for over two years has given quite three times the yield of mustard on the untreated areas : the results with indigo seed will be much in the same proportion.* When applied to poorer lands the difference in both mustard and indigo seed is even more marked than in the better

[1] That the failure of indigo is not due simply to indigo following indigo in the same lands is clear from the fact that on many estates now indigo fails badly in lands which have been leased out to *raiyats* and have not grown indigo for 3 or 5 years.

[2] "The Phosphate Depletion of the Soils of Bihar," *Agricultural Journal of India*, Special Indian Science Congress Number, 1917, p. 77.

quality lands, **in some cases the yield being half a maund or no crop at all in untreated land as against 4 maunds with phosphate.''** As regards the yield of *green plant* Mr. Coventry stated—" the increase is very great, sometimes half as much again in the first cutting and double the quantity in the second cutting." Where no phosphate was applied the mustard plant frequently died out entirely and the indigo failed to give a second cutting : where superphosphate was used, an excellent mustard crop was obtained.

It should carefully be noted that the maximum effect of super on indigo does not show in the first year, as it takes time to wash down into the subsoil where the indigo feeds—it is the subsoil which is now most deficient in phosphate. Mr. Bernard Coventry writes to me in connection with past trials with superphosphate at Dalsing Sarai—**" The residual results were very remarkable and the considerable profits which Dalsing Sarai made in the years following the application were attributed to it by my brother. Though the expenditure was considerable yet both the immediate and residual effects fully justified it."** In this case half the total cultivation was treated with superphosphate—about 3,000 acres in all—so that the results are those of actual large scale working.

The manurial experiments made at Pusa[1] have shown that the yield of cereals (maize or oats) is *doubled* by treatment with super alone (as compared with no manure) whilst when super is used in conjunction with green manure (the best form of manuring for cereals) the crop has been increased three- to four-fold. Mr. M. M. Mackenzie has stated that by manuring with superphosphate plus green-manuring at Sapaya the *average out-turn* of oats per acre has been doubled in three years.

	Mds. of 80 lb.
1st year average out-turn per acre	12·00
2nd year " " " "	19·50
3rd year " " " "	23·00

I think it highly probable that by systematic manuring for a period of 5 to 10 years with superphosphate it should be possible gradually to bring back the yield of the Java indigo plant to a high level and that estates on which the yield of indigo has dropped

[1] For data, *see* my article "The Phosphate Depletion of the Soils of Bihar."

to 5 to 6 seers per acre would be able in time to yield 20 to 25 seers, yields which are clearly possible in Bihar, in the light of the Belsand experience (*see* Table IV).

The question of such manuring is one of great importance not only in regard to indigo but also to other crops grown on planters' *zerats*. A good crop of indigo greatly improves the land for subsequent cereal crops, not only by its yielding a good supply of *seet* as a manure, but by its direct action in increasing the supply of nitrogen in the soil—the principal food required by the cereal crop. The great value of the *seet* is well known to planters—in many cases land manured with *seet* is subsequently let to *raiyats* for growing other crops such as tobacco, and the increased rent willingly paid by the *raiyat* for such seeted lands is often surprising.

The present day planter is not merely an indigo manufacturer as in the old times, but a general farmer, and a large part of his income is derived from other crops following indigo and from manured land let to *raiyats* for special crops (tobacco, chillies, etc.). In fact several planters have told me that the other crops grown (with the aid of *seet*) nearly or entirely pay all the costs of the estate. Whatever indigo is made is clear profit—the actual costs of manufacturing indigo are small. Now by proper manuring with superphosphate not only can the yield of *indigo itself* be greatly improved but the yield of manure (seet water and *seet*) will be greatly increased also (from 50 to 100 per cent.). Thus the lands can be more intensively manured for other crops which follow indigo. The experiments at Pusa and other places in Bihar have shown that by proper manuring with super and green manure, the output of other crops, especially cereals, can be doubled in a few years (*see* the Sapaya results above) or even trebled. The more *seet* there is available the higher too will be the rent which can be demanded for lands let out to *raiyats*.

If at the present time crops other than indigo largely pay the costs of working the estate, the increased yields of such crops caused by manuring should be clear profit which would enable the indigo itself to be sold at a cutting rate to keep down competition of the synthetic. It must be clearly borne in mind that the

indigo is grown not merely for itself but largely for its effect in enriching the soil by the direct assimilation of nitrogen from the air and by its providing large supplies of *seet* which greatly enhances the value of the land by its manurial qualities.

That the above picture of the cumulative advantages of phosphate manuring is not a fanciful one but is capable of certain realization is clear from the actual history of agriculture. In fact the position of Bihar to-day appears strikingly similar to that of England nearly a century ago. Large towns were then growing up and the continual removal of crops and dairy produce, especially the latter, to the towns, rapidly impoverished both soil and pasture. The introduction of the manufacture of superphosphate by Sir John Bennet Lawes shortly after 1845, had a marvellous effect on fertility throughout the whole country and on the yield of dairy produce. Not only was the pasture land revived by the *direct* action of the phosphate but far larger crops were obtainable from arable lands, especially root crops, and it thus became possible to keep more cattle. These indirectly helped fertility (especially in the case of cereal crops) by supplying larger stocks of farmyard manure, and a rapid improvement of the soil became general throughout Great Britain.

That similar surprising results have followed the use of superphosphate wherever the soils are naturally deficient, is also a matter of history. The writer, when working at the Rothamsted Station, has been repeatedly assured by visitors from Australia that probably the principal factor in the prosperity of Australian agriculture has been the introduction of phosphatic manures there, which by increasing the fertility of the soil made it possible enormously to increase the number of sheep and cattle reared in that country and so at the same time greatly to increase the output of wool. Here again the effects of the making good of one single deficiency in the soil, reacted cumulatively in half a dozen directions and so greatly increased the general wealth of the community. To the writer it seems certain that similar advantages would accrue from the widespread adoption of phosphatic manuring in Bihar.

The penalty of procrastination.

The time factor is an important one in the coming struggle between natural and synthetic indigo. If proper manuring trials be not immediately instituted it appears certain that in the next few years the indigo crops throughout Bihar will fall off in an alarming way. The kind of thing to be expected can be judged from the actual example of Belsand—where in the four years between 1908 and 1912 owing to the spread of "wilt," the output of indigo fell from 604 maunds to 220 maunds on a slightly increased area. Recently several cases have been reported to me of the complete failure of August and October sowings at an early stage of growth. One of the most interesting is that of a field which was sown during the rains (July 1917) for a Java seed crop. The seed germinated well but after the plant had reached a height of 6″ it became diseased and gradually died out—it never reached a height of more than 18″ and by October nothing was left but thin sticks. The land was then harrowed and re-sown in October for a Java manufacturing crop. Again the plant germinated well but the small plant soon became diseased and largely died out. The land was then re-sown with Sumatrana plant early in March: again there was a good germination but by the end of March the plant had again completely failed. Here three successive sowings of indigo which germinated well died out after reaching the height of a few inches. I have met numerous similar cases in different parts of Bihar. Fields which several years ago gave good yields of indigo now fail to give crops at all—or poor, diseased and stunted crops. Last year (1917), as already pointed out, owing to the general failure of *khoonties*, the yield of indigo in Bihar fell off by 17 per cent. as compared with 1916.

It is certain that possible improvements in **manufacture** alone—although these are very considerable—can effect relatively small increases in total yield unless attention is also given to remedying the exhaustion of the soils. This is obvious from the fact that if the crop falls to about one half during the next few years—and at Belsand the actual falling off in four years was 65 per cent.—any large increase (say, even 40 per cent.) in output which can be

effected in the future by improved methods of manufacture will, on the *half crop remaining*, fall very far short of balancing the enormous loss in the crop itself—in fact there will still be a loss of 30 per cent. as compared with the present yield per acre, using the present unimproved methods of manufacture. On the other hand, if the crop were increased by manuring by 100 per cent.—and I consider such an increase could be realized in a few years—and at the same time a 40 per cent. increase in yield of produce were practicable on the *increased* crop, the total indigo produced per acre would be increased nearly threefold. This is clear from the following numbers :—

Present crop per acre taken as 100 yielding only 70 parts of its indigo.

Present crop doubled by manuring as 200 yielding with improvements the whole of its indigo, 200 parts.

Unless estate manurial trials be started immediately it appears to me certain that the next few years will witness a very large falling off in the output of natural indigo. This will happen at the time when competition with the synthetic is most severe and it is most important to have a large output in order to be able to sell at a low price to compete. Unless proper phosphate manuring be adopted—and that rapidly—the natural dye will be seriously handicapped in the next few years and its final extinction rendered certain.

Eighteen months ago I pointed out the relationship between the phosphate deficiency of the soil and the wilt disease of indigo in Bihar and have since been constantly advocating the necessity of superphosphate as a manure. With a few exceptions, planters have, however, as yet, not made up their minds to carry out manurial trials on their own estates—each one apparently is waiting to see what his neighbour does. In this case time is precious—the superphosphate acts slowly as a rule, and if competition with synthetic is to be met in the near future, each planter must *make trials* to ascertain which fields on his estate best respond to treatment with superphosphate, so as to be in a position to take up manuring on a large scale within the next few years. If the industry is to be

restored a considerable outlay on superphosphate manures will be required in the next few years. The large profits realized by indigo estates since the war should facilitate such an outlay: it remains to be seen whether the remedy will be taken in time.

(To be continued.)

RAINFALL, IRRIGATION AND THE SUBSOIL WATER LEVEL OF THE GANGETIC PLAIN IN THE UNITED PROVINCES OF AGRA AND OUDH.

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[Continued from vol. XIII, page 205.]

II. THE WELL-IRRIGATED TRACT.

TABLE I (vol. XIII, p. 204) shows the agricultural and irrigation statistics of this tract for the famine years of 1896-97 and 1907-08 corrected in the manner already explained to show the total area irrigated during the year.

The total area irrigated in 1907-08 shows an increase of 32·3 per cent., it was 31·2 per cent. of the total cropped area of the year and 35 per cent. of the normal cultivated area. The corresponding figures for the same year for the canal tract were 50·6 per cent. of the total cropped area of the year and 56 per cent. of the normal cultivated area, figures which show how much better protected against famine this latter is. Except for some small areas in Muttra and Cawnpore and a considerable area in Agra, Fatehpur, and Allahabad, the canal tract is completely protected against famine, whereas the well tract is not so. Wells in numbers can do much to mitigate the effects of a famine, but they cannot save the *kharif* crop and the cattle give out under the stress of constant irrigation.

Comparing the *ek-fasli* figures for irrigation from wells and other sources it will be seen that well irrigation in 1907-08 shows

the remarkable increase of 49·4 per cent. due to the great increase in the number of wells since 1896-97 ; on the other hand irrigation from other sources shows a decrease of 19·3 per cent. due to poorer supplies in the *jhils*.*

The *ek-fasli* area irrigated per well in use in 1907-08 was just 3 acres.

The alluvial deposits of sand and clay underlying the Gangetic plain are of unknown depth ; they have been proved by borings at Lucknow to a depth of over 1,000 feet.

The subsoil strata may roughly be said to contain 33 per cent. of open pore space which below the water table is filled with water : this will, however, yield to pumping about 25 per cent. only, as a certain percentage clings to the particles of silt and sand and cannot be dislodged by gravity.

The total area of well irrigation in this tract in the famine year of 1907-08 was the maximum hitherto recorded, *viz.*, 2,100,000 acres approximately ; the total area of this tract is in round figures 12,800,000 acres, about six times as great.

If the depth of water used in well irrigation be taken as 8 inches, a full average for three waterings, this depth is equivalent to a depth of only 1·3 inches when spread over the whole area ; in other words, the draught on the wells, if considered equally distributed over the whole area, would have lowered the ground-water level about 5 inches.

In the absence of any artesian action the rainfall over this tract must be the sole source of supply of the ground-water. Pilibhit, however, in the north of this tract, no doubt receives some contribution through seepage from the rainfall on the area to the north of it which eventually finds its way to lower levels.

The mean annual rainfall of this tract is 38·60 inches, and, as will be shown later, about 12 inches of this percolates through the upper strata of soil to raise the ground-water level, which from what has been already stated would raise the level about three feet. As to how much this is reduced by seepage during the year is quite unknown ; it is clear, however, that the effect must be

* Natural depressions in which water accumulates during the rains.

considerable and sufficient to keep the subsoil water level within certain limits in spite of the low velocity of underground flow.

Surface evaporation would appear to play no part except where the water table rises to near the surface, for 7—10 feet appear to be the limit of capillary action even in certain fine soils.

The above figures, even if only approximately correct, as it is believed they are, show that the draught on the subsoil water even in a famine year is but a small fraction of the increment of percolation from the mean rainfall, and that therefore the subsoil water supply is for all practical purposes inexhaustible.

It is not contended, however, that excessive draught on the underground water within limited areas might not result in a permanent lowering of the water table.

The Amritsar pumping scheme is based on this expectation. This work which will shortly be put in operation will be the first serious attempt in this country to correct by pumping from tube wells, sunk from 100—200 feet below ground, an undesirably high spring level over an area of some six square miles due to the combined effects of seepage from the canal and over-irrigation : the water thus pumped will be used for irrigation instead of water from the canal.

This work should afford valuable information as to its effect on the water table in view of the further extension of power pumping from tube wells in the near future. These in Oudh are so few in number at present, and each of the comparatively shallow percolation wells abstracts so small an amount from the underground supply, that, even in limited areas, we appear to be within no measurable distance of the time when the increase in the number of such wells is likely to lead to a permanent fall of the water level to so serious an extent as to affect their working, and we must therefore look for other reasons for the continued fall in the subsoil water level in recent years, which has been the cause of considerable anxiety amongst the cultivators of Oudh.

The first mention in the Season and Crop Report that the subsoil water level had fallen to a serious extent occurs in the year 1908-09. In 1909-10 and 1910-11 there were no complaints : in 1912-13 it is stated that the fall continues and, in the words of the

Commissioner of Lucknow, "threatens to be a very serious calamity"; in 1913-14 it is stated, "the dry season and urgent demand for water for irrigation purposes brought into prominence the falling of the water level in parts of Oudh. It is reported the districts most affected are Unao, Sitapur, Hardoi, Lucknow, and Kheri, and to a lesser degree Partabgarh and Sultanpur. Further, that the fall is more marked in particular areas than in others, *e.g.*, in a comparatively limited area round the town of Safipur in Unao District the fall was not less than 8—10 feet, while in the adjoining country it was insignificant and not sufficient to render the wells unserviceable. The same feature was noticed in Sitapur District and also in Hardoi."

It is of course a matter of common knowledge that the water level rises quickly after a year of good rainfall but falls slowly after a year of bad rainfall. Of the total annual rainfall, part is lost by direct evaporation from the surface of the soil, part by the transpiration of trees and plants, part by the interception of trees and plants, and a varying proportion of the balance, dependent on the moisture content of the soil, percolates under the forces of gravity and capillarity through the upper stratum of soil into the subsoil. One of the effects of this movement of water is to raise the subsoil water which slowly finds its way to lower levels. The rate of flow of seepage and underground water depends upon a number of factors, the chief of which are : (1) the available head or gradient; (2) the relative porosity of the soil; and (3) the temperature of the soil and water. According to Prof. C. E. Schlichter, an American authority on the subject, the velocity is only one-tenth of a mile per annum in a fine sand with grains of 0·20 m.m., having a porosity of 32 per cent., and a temperature of 50°F. under an hydraulic gradient of 100 feet per mile. French engineers are agreed that, even in coarse water-bearing sand, the velocity of flow does not exceed one mile per annum. It is clear that in Oudh with a much flatter hydraulic gradient than 100 feet per mile the movement of ground-water is extremely slow. In considering the question of the ground-water supply and levels it is very important to have some idea of what proportion of the normal rainfall reaches the subsoil to replenish the ground-water supplies.

Evaporation and Drainage.

The only records of any observations made in India that have been published, as far as I am aware, are those described in the Records of Drainage in India by Dr. J. W. Leather,[1] from which the following facts are abstracted. The observations at Cawnpore with two drainage gauges six feet deep, the surfaces of which were maintained fallow but not allowed to become compacted, furnish us with some idea of what proportion of the annual rainfall percolates through the good, well-cultivated soil of the Indo-Gangetic alluvium.

As a result of five years' observations, 1904-08, with an average annual rainfall of 31·4 inches the drainage was 12·3 inches or 38·2 per cent. and the evaporation 19·1 inches or 61·8 per cent. In 1903-04 when the rainfall was highest, *viz.*, 46·51 inches, the drainage was 21·25 inches and the evaporation 25·26 inches; in 1904-05 when the rainfall was lowest, *viz.*, 20·61 inches, the drainage was 3·14 inches and the evaporation was 17·47 inches, figures which show how much the percolation depends on the rainfall and that, as Dr. Leather states, the amount which evaporates during the 12 months at any place is almost constant or at least varies in only a subordinate degree and is generally highest in a wet year, conclusions which are confirmed by similar observations in England. Since the whole of the rainfall was impounded on the surface of these gauges the results do not take into account the surface flow off the ground which takes place, to a limited extent, even in a monsoon of low rainfall of which the increased supplies in the local rivers, streams, and *jhils* are evidence. The results, therefore, for both evaporation and drainage, especially the latter, are undoubtedly in excess and require correction to allow for surface flow-off. The above results are for gauges kept fallow and it is necessary, since any tract of country is partly under crops, trees, or grass, to consider the effect of cropping, for it is evident that the quantity of water found to be evaporated from fallow soil will be less or greater than that evaporated and transpired from that under crops, according as the effect of protection is less or greater than transpiration.

[1] *Mem. Dept. Agr., India*, Chem. Ser., vol. II, no. 2.

According to Dr. Leather, the effect which crops have on the amount of drainage and evaporation is the result of several factors, *viz.*—(1) the amount of water transpired depends largely on the weight of the crops : each crop has a transpiration ratio peculiar to itself, but the variations in the magnitude of such ratios are generally small compared with the differences in the weight of the crops ; (2) a growing crop protects the soil moisture more or less from evaporating into the air ; the normal circulation of the air over the soil is retarded and the air within the crop is thus maintained in a highly saturated condition, at the same time the plant reduces the amount of water in the surface soil. The observations on the cropped gauges, both at Cawnpore and Pusa, are too few in number to draw very definite conclusions from, but, as far as they go, they indicate that the effect of a crop is to reduce the evaporation of the soil and that a good crop, while transpiring large amounts of water, reduces the loss of moisture by evaporation from $\frac{2}{3}$ to $\frac{1}{2}$ of that from fallow land.

Surface Flow-off.

The annual flow off a catchment is most difficult to estimate as it depends on so many factors, *viz.*, the amount and duration of the rainfall, especially the hourly rate of fall, the condition of the ground when the rain falls, the season of the year, the area and configuration of the catchment area, the character of the soil, and the cultivation and cropping of the land.

For the well tract under consideration the run-off in a year of average rainfall might be 15 per cent. of the monsoon rainfall and in a year of minimum rainfall only 5 per cent. of the same. The only method, however, of ascertaining with any degree of accuracy the loss by seepage and the surface flow-off from any catchment would be extended gaugings of the streams which drain such catchments.

Interception.

There are no data available of the amount of the rainfall lost by interception of trees and growing crops and evaporated without ever reaching the ground. Probably some 10 to 15 per cent. of the rainfall is ordinarily so intercepted. If sufficient data existed it

would be possible to make an estimate of the amount of the various losses for this particular tract; out of a gross area of nearly 12,833,000 acres, about 410,000 acres are under forests and groves, 1,900,000 acres are designated as not available for cultivation, mostly under grass or scrub jungle, 3,000,000 acres are cultivable waste, also mostly under grass or scrub jungle, and the balance of 7,523,000 acres represents the normal cultivation, this latter at different periods of the year is either under crops or lying fallow and may be tilled or untilled.

Evaporation and Transpiration Losses.

There are no data as to the evaporation or transpiration losses of an area under forest trees. Generally transpiration losses are very large, but owing to mulch, shading, and protection from wind, direct soil evaporation is small. Probably the best estimate of water losses by transpiration could be made from direct observation as to the state of development of the crop or the amount of dry matter developed. A determination of the transpiration losses by this method involves three factors: (1) the area covered by a given kind of vegetation; (2) the transpiration depth per unit or crop yield; and (3) the average crop yield per acre.

The data for (1) and (3) for any year can be obtained from the statistics of the Agricultural Department. Data as to transpiration losses in terms of crop yield are very few at present. This method of estimating transpiration losses is admittedly approximate, but has at least the merit of being founded on matters capable of direct observation.

Little information is as yet available as to the evaporation from soil under crops; this too must vary with the degree of cultivation. The fallow surfaces of the Cawnpore and Pusa gauges were untilled, and the results for surface evaporation are of course higher than for tilled soil; in the case of this latter too surface flow-off would be diminished while drainage would be increased.

The evaporation loss from a soil surface, according to Horton, is the product of two factors, evaporation rate and evaporation opportunity, this second being a term involving the degree and duration of moisture in the soil. In general the evaporation

opportunity is less than unity and consequently the evaporation loss from a soil surface is less than that from a free water surface subject to the same conditions of evaporation rate. He also states that most existing evaporation formulæ are in error in that they involve a linear factor for wind correction such that wind effect apparently increases indefinitely as the wind velocity increases. He states that it has been proved experimentally and is moreover indicated by physical considerations that, since the wind can do no more than remove the water vapour as fast as it is emitted from a water or soil surface, there is a maximum or limiting value of the wind factor corresponding to each surface temperature, and that apparently this value corresponds to a wind velocity of about 15 miles per hour. The data regarding evaporation from soil surfaces in this country are at present too few to frame any fairly close estimate thereon.

The following figures as to the disposal of the mean rainfall of this tract are given by me with some diffidence but after a study of such data as are available.

	Inches
Surface flow, 15 per cent. of the *kharif* rainfall of say 37 in.	5·5
Interception	1·5
Evaporation	15·0
Transpiration	4·5
Drainage	12·1
Total ...	38 6

It may, I think, be stated with some confidence that the drainage is between 10 and 14 inches. In 1907-08 only 54 per cent. of the normal rainfall was recorded or 20·84 inches. As already stated the quantity evaporated is nearly independent of the rainfall and the following figures give some idea of its disposal.

	Inches
Surface flow, 5 per cent. of *kharif* rainfall	1·0
Interception	1·0
Evaporation	15·0
Transpiration	4·0
Drainage	...
Total ...	21·0

It is fairly evident that in such a year not only was there no drainage, but there was also some reduction in the moisture content of the upper strata of soil which is in accordance with fact.

The figures given are but approximate, based on the best data available, but, considering the large number of various factors involved, probably a more satisfactory method of ascertaining what proportion of the rainfall percolates to raise the ground water level would be to select a certain number of the non-irrigation wells outside the influence of the canals and at which the water level has been observed for some 30 years, and to endeavour to correlate the rise of the water level between the May and November observations with the rainfall: the fall between the November and May observations would indicate for this period the effect of the subsoil flow. I regret I have not with me the necessary data to attempt this.

Table II shows the mean annual rainfall, together with the variations from the mean for each year from 1901-02 to 1915-16 for each district in the tract under consideration: it shows that from 1901-02 up to 1914-15 the annual rainfall was rarely and then but slightly above the mean, that it was frequently in considerable defect, and that it was not in any considerable excess until 1915-16: it also shows that the total deficiency up to 1913-14 amounted in most districts to a year's mean rainfall and in a few districts, *e.g.*, Pilibhit, Unao, Sultanpur, Hardoi, and Kheri to considerably more than this. The period of greatest deficiency was from 1905-06 to 1908-09.

For this tract as a whole (*vide* Table III), the deficiency was so great in two consecutive years, *viz.*, 54 per cent. of the mean in 1907-08 and 65 per cent. in 1908-09, that it is probable that the rainfall contributed little, if anything, to the subsoil water supply: while at the same time, the water level was being steadily lowered by seepage into the rivers and streams and also, but to a much smaller extent, by the steady draught of water for irrigation from wells, *jhils*, and streams.

If all these facts be taken into consideration it is not surprising as the result that there has been in recent years, *viz.*, from 1908-09 up to 1914-15, a considerable and more or less continuous fall of the subsoil water level over the whole of this well tract.

The whole of this well tract is remarkable for the large number of *jhils*, either shallow and isolated depressions, or chains of such

Table II.

District	Normal rainfall	Variation from normal rainfall															
		1901-02	1902-03	1903-04	1904-05	1905-06	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	1901-02 to 1913-14	1905-06 to 1908-09
Shahjahanpur	36·72	−0·02	−9·82	+8·68	−1·22	−12·15	+1·10	−7·10	−11·03	−1·05	+8·63	−2·35	−5·02	10·28	+3·00	+14·57	−41·63	−29·18
Pilibhit ..	50·03	−1·33	−2·93	+3·27	−3·23	−12·54	−10·33	−21·24	−4·66	+8·86	+11·21	−7·10	−7·95	−25·86	−0·67	−5·48	−73·83	−47·34
Lucknow ...	35·66	−5·46	−8·06	+6·44	+5·44	−6·37	+10·00	−20·19	−5·64	+8·48	−5·16	−3·60	−3·45	−6·97	+1·72	+33·44	−34·54	−22·20
Unao ...	33·59	−5·29	−7·59	+2·71	+15·51	−12·89	−2·93	−16·27	−12·15	+2·71	−2·45	−5·17	−7·22	−12·58	−3·71	+28·43	−63·62	−44·24
Rae Bareli ...	36·27	−8·37	−4·17	−0·87	−2·47	−11·36	+0·56	−14·90	−10·12	+6·78	+4·28	+2·12	+3·23	−5·92	+0·17	+12·11	−41·21	−35·82
Partabgarh ...	37·66	−6·36	−1·96	+17·84	−1·66	−3·91	−3·01	−7·73	−14·15	+9·70	+7·21	+1·82	−5·25	−5·87	−2·48	+13·39	−13·33	−28·80
Sultanpur ...	41·23	−14·63	−7·53	+13·67	−7·93	−4·12	−4·45	−21·13	−20·11	+4·26	+2·28	+3·37	−10·42	−9·28	+2·78	+14·65	−76·02	−49·81
Sitapur ...	36·81	−0·71	−1·91	+1·49	+2·39	−3·41	+0·74	−19·09	−15·66	−1·35	+4·85	+0·43	+1·20	−9·10	+10·10	+29·45	−40·15	−37·42
Hardoi ...	34·78	−2·98	−5·78	+4·32	+7·82	−13·09	−2·11	−20·21	−16·03	−1·90	−3·42	−7·56	−2·28	−12·67	−3·83	+17·01	−75·89	−51·44
Kheri ...	43·59	−5·49	−11·79	−0·69	−0·69	−12·83	−4·50	−26·89	−17·80	+3·43	+7·76	−6·16	−8·85	−16·56	−0·32	+13·27	−101·09	−62·02
Barabanki ...	38·27	−7·87	−2·67	+8·53	−2·37	−12·35	+6·48	−20·35	−19·52	+25·81	+8·01	+4·08	+1·20	−12·57	+12·52	+27·20	−43·57	−45·72

Table III.

	Normal rainfall	Percentage of normal rainfall														
		1901-02	1902-03	1903-04	1904-05	1905-06	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16
Canal tract	30·14	73	89	102	115	54	110	57	104	105	111	84	98	60	119	92
Well tract ..	38·60	86	85	115	103	74	98	54	65	111	110	95	89	70	106	147

separated from each other by high necks which are overtopped only in a good monsoon : these depressions are largely resorted to for irrigation.

In the dry year of 1899-1900 the total irrigation from "other sources," *i.e.*, *jhils* and streams, was 842,137 acres ; in the famine year of 1896-97 the area so irrigated was 439,891 acres, and in that of 1907-08, 354,868 acres ; these figures show that the available supply from other sources, chiefly *jhils*, was considerably less in this latter year.

This well-marked feature of this tract has, without doubt, a considerable influence, especially locally, on the subsoil water level. One of the benefits which result from the construction of reservoirs and tanks in Bundelkhund is a general rise of the water in the wells in their proximity, and there is not the least doubt that these depressions when holding water have the same local effect and that their wide-spread distribution accounts in a large measure for the somewhat high subsoil water level over many parts of Oudh.

In years of light rainfall the surface flow-off is but small or even nil, and in consequence these depressions are not filled, and, moreover, soon after the close of the monsoon they are quickly emptied by irrigation : the effect of such seasons on the subsoil water level, more particularly in the areas around these depressions, is considerable, and the same effect would be realized when these *jhils* are drained in order to reclaim the land to cultivation as has already been experienced at Safipur where the considerable fall in the level in a comparatively limited area must be due to drainage operations on the top of a series of years of short rainfall. The fall of the subsoil water level in Oudh in recent years and which has been more particularly marked in limited local areas is thus sufficiently accounted for.

The monsoon rainfall of 1915 was very heavy, *viz.*, 47 per cent. in excess of the mean, and in consequence it is reported that the *jhils* were filled to overflowing and the subsoil water level not only rose to its former level but beyond it.

A word of caution is here necessary anent the Sarda Canal which it is proposed shall be brought into this tract. As an

argument in support of it the statement has been made that the water level generally in Oudh is not as high as had previously been supposed. Undoubtedly, as a result of a series of years of short rainfall, the ground-water level has been falling and about 1914-15 it was probably at its lowest for many years past; this, however, affords no reason for doubting the correctness of the recorded observations of Major Forbes and Mr. King. It is evident that the ground-water level is subject to considerable fluctuations dependent on the season's rainfall.

The introduction of the Sarda Canal into this tract will tend to raise the water level. This tendency can be counteracted by keeping the canal bed above the clay sub-stratum wherever this exists and by puddling the canal channel elsewhere, also by efficient drainage measures: the natural drainages must be improved and artificial drains constructed to drain the large number of *jhils* of their contents, which are responsible in no inconsiderable degree for the generally high level of the subsoil water throughout Oudh: such drainage, moreover, will reclaim to cultivation thousands of acres of good land which can be irrigated from the canal.

In conclusion, it has been shown that the marked and more or less continuous fall of the subsoil water level in Oudh between the years 1908-09 and 1914-15 was undoubtedly due to a series of years of deficient rainfall, and that in two consecutive years, *viz.*, 1907-08 and 1908-09, little, if any, of the rainfall could have percolated to the ground-water table. It has also been shown that the draught for irrigation on the ground-water, even in a year of severe drought, is but a small fraction of the increment received from the mean annual rainfall, and, therefore, if we average the present draught over a series of both wet and dry years the effect in the direction of causing a permanent fall in the water level must be very small indeed, and there appears to be no reason on this account to call a halt in the further construction of wells.

Finally, from what has been stated above, it is clear that there are many problems connected with seepage from canals and the ground-water level which await investigation.

LAND AND LABOUR IN A DECCAN VILLAGE*: A REVIEW.

BY

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SUCH endless discussions have taken place in the past regarding the exact economic situation of the Indian cultivator, and so many divergent views, based on general statistics, vague information and personal opinion, have been expressed on the subject that it is very refreshing to find an attempt being made to record the exact economic details of a single, typical Indian village. Such an attempt has been made by Dr. H. H. Mann, Principal of the Poona Agricultural College, and three of his assistants, and recorded in a publication issued by the University of Bombay. The enquiry is thorough and detailed, and the record illustrated by maps, diagrams and photographs which add considerably to the interest of the book from the point of view of the general reader.

The first two chapters deal with the physical features of the village, the climate, geology, soils and waters, which are typical of a large tract in the Bombay Deccan. The account given of these matters is clearly expressed and cannot fail to be of interest to any one belonging to this locality, while the information regarding such matters as soil-formation and subsoil water are of considerable value to all for whom these subjects have more than a passing interest.

Chapter III deals with the land and its divisions, giving an account of the holdings, *inams*,† and revenue history of the village from

* By Harold H. Mann, D. Sc., and others. Oxford University Press. Price Rs. 2 or 3*s.* 6*d.*

† A form of land tenure which carries partial or complete exemption from the obligation to pay revenue.

1700 to the present day, showing how large a part of the revenue was alienated to individuals and temples, and for presents, festive occasions, and charity in the olden days when the Peshwas were able to draw large revenues from other parts of India. In the present day there are 140 holdings, aggregating 1,006 acres, assessed at a total of Rs. 1,660. Perhaps the most remarkable figures in this chapter are those which show how the holdings have become subidvided under the existing laws of inheritance, as the population has increased. In 1771 the average size of the holding was 40 acres. By 1818 it had fallen to 17½ acres. From 1820 to 1840 it remained constant at 14 acres, and by 1915 it has been reduced to 7 acres. Of the total number of holdings 81 per cent. are now under 10 acres in size, and 60 per cent. under 5 acres. Further, these holdings have been fragmented into 729 separate plots of which 463 are less than an acre, and 112 less than ¼th acre.

The actual farms, as now separately cultivated, consist of 109 holdings in 741 separate plots ; which means that the average farm, as cultivated, consists of 9 acres, broken up into 6 or 7 plots.

Now what results might be expected from such conditions ? On general principles it would be extremely probable that these holdings, subdivided below the economic limit and greatly fragmented in addition, would be badly cultivated, and that no permanent improvements or progressive development of the land could be secured. This is, in point of fact, exactly what we find. There is a river in the village containing perennial water of good quality, which would readily lend itself to irrigation, and also two large *nalas** which contain water for some time after the monsoon. The water of these is not used at all for irrigation. Eleven wells, built in former times, contain a fair water supply ; but even these are little used for irrigation, and the people give as a reason for not making better use of the water, the fact that the land has been so much subdivided, and that the wells usually belong to several co-sharers in what was originally one holding. The damage to the lands by surface scouring and deep gullying in sloping lands is

* Ravines or water courses.

recorded, and it is also noted that very little effort is made to remedy this. To quote the authors' words :- "The limit of effort in this village has been in a few cases to level and embank fields which are actually nearly level, and to divert streams of water, which would be likely to damage the fields, either on to someone else's property or on to the roads and footpaths in the village." No mention is made of any other improvements to the land, and it may be confidently assumed that none have been made. In short, the net result of excessive subdivision and fragmentation of the land has been to preclude all idea of steady development, and, to some extent, to render useless such improvements as were made in times before this excessive subdivision of land had taken place.

The nature and condition of crops are dealt with in the next chapter. As might be expected from the economic conditions, the situation is anything but satisfactory. There is little intensive culture, few valuable crops are grown, and the out-turn of the crops grown is very poor. *Jowar* (*A. Sorghum*) and *bajri* (*Pennisetum typhoideum*) are the main crops produced. Indeed in 1913-14 no less than 770 acres were under these two crops out of a total cultivated area of 874 acres. The more valuable crops grown are wheat, carrots, peas and groundnuts ; while sugarcane is occasionally grown in very small areas. As regards gross out-turns it is estimated that on fair lands *jowar* gives Rs. 31 per acre, *bajri* Rs. 21-8-0, wheat Rs. 30-2-0, and groundnut Rs. 50-12-0, and that in order to get the general average, even in good years, a reduction of from 10 to 20 per cent. must be made. The figures given below compare the out-turns obtained on the Government farm at Poona, under similar conditions, with those estimated for this village :—

Value of out-turn per acre.

	Obtained by the *villagers*		Obtained on the *Government farm*	
	Rs.	As.		Rs.
Jowar	... 24	13	Kharif	55
			Rabi	80
Bajri	... 17	4		38
Wheat	... 24	2		53
Groundnuts (Pondicherry)	...	14		99

The out-turns on the Government farm are secured by methods of clean cultivation, timely operations, and proper rotations. They represent the actual average for 5 years, taking good and bad years alike. It must therefore be conceded that the results obtained in the village are very poor, since they represent in every case less than half the out-turns obtained on the Government farm. It is also a remarkable fact that in the village the cultivators make no attempt to cultivate cotton, chillies, or onions, which on the Poona farm have given the profitable results shown below ;—

	Value of out-turn. (*5 years' average*)
Cotton	Rs. 74
Chillies (unirrigated)	Rs. 192
Onions (irrigated for 3 months)	Rs. 177

Perhaps the most interesting chapter, however, is Chapter VI, where under the heading " The People " the authors calculate the income of the village and draw their conclusions as to the solvency, standard of living, and general well-being of the population.

It is to this that the whole of the argument works up, and it might have been hoped that this part would have been clearer and more explicit than it is. On page 137 is given what is described as the " balance sheet " of the village ; but in point of fact it is nothing like a balance sheet, and is not complete or very intelligible even as a " Profit and Loss Account " which is apparently what it aims at being for 103 out of 111 families in the village. This is a pity, because the details given in the book are sufficient to construct a rough " Profit and Loss Account " for the village, which would direct attention to some of the most remarkable features in the economy of the village, which are now completely obscured. The " Profit and Loss Account " for the village for the year 1915-16

works out as follows on the basis of the figures recorded in the book:—

Profit and Loss Account of the village for the year 1915-16.

Profit—			*Loss*—		
Total value of ordinary crops		Rs. 18,720	Land Revenue		Rs. 1,660
Value of produce from fruit trees and *babul* (*A. arabica*)		Rs. 409	Seed		Rs. 1,233
Value of dung cakes prepared		Rs. 1,200	*Cost of feeding cattle*		
Value of milk produced		Rs. 4,866	(*a*) 108 bulls and bullocks, at Rs. 60	Rs. 6,480	
Value of *gul* (raw sugar) made		Rs. 3,780	(*b*) 80 calves at Rs. 20	Rs. 1,600	
Gross income from land		Rs. 28,975	(*c*) 96 cows and she-buffaloes	Rs. 4,866	
Wages earned outside the village		Rs. 13,503			Rs. 12,946
Total		Rs. 42,478	Money leaving the village on account of wages for cultivating sugarcane and making *gul* (say)		Rs. 2,000
			Total outgoings		Rs. 17,839
			Net annual profit of the village		Rs. 24,639
			Total		Rs. 42,478

The totals arrived at in this way are substantially the same as those arrived at in various parts of the book, and the only difference is that whereas in the book the method by which the net profits were arrived at is not explained, the Profit and Loss Account given above indicates the method by which the calculation is made. In view of the smallness of the holdings and the superabundant labour in the village, it has been assumed that all the labour used in producing the crops is labour of the village, except in the case of sugarcane for which it is specifically stated that outside labour is always employed, and for this a debit has been made. The only item entered above which seems to be doubtful is Rs. 4,866 as the cost of feeding the cows and buffaloes. This figure is the same as the value of the milk said to be produced in the village. No credit for the value of the milk was made in the so-called balance sheet on page 137, and it is therefore assumed that the cost of feeding and the value of the milk produced are held to balance each other. The omission of any credit entry for milk may have been an oversight, but in any case the net profit would not have been large, and the argument remains substantially unaltered. It may also be remarked in passing that the area cultivated in 1915-16 was less by 121 acres than the normal

(*vide* page 67), so that in an ordinary year some Rs. 2,000 would have to be added to the net profits of cultivation in the village.

The authors call attention to the very small gross return per acre, and this point deserves all the notice that they give it ; but what is even more remarkable is the fact that the cost of maintaining the bullocks and young stock amounts (at a very moderate computation) to Rs. 8,000, a figure which is nearer $\frac{1}{2}$ than $\frac{1}{3}$ of the total value of the crops. In other words, under the existing system the maintenance of the work-cattle is a dead-weight on the industry which economically it cannot support. This is a matter of prime importance and denotes a problem to which the old books on French farming all refer ; but it is impossible to enlarge on the subject here.

An even more surprising result is obtained by comparing the earnings from cultivation in the village with the earnings from sources other than cultivation. Apparently 119 men and 2 women who engage in non-agricultural labour can, working without capital, earn Rs. 13,503 in the year, which amounts roughly to Rs. 9-4-0 apiece per mensem. Considering the current rates of wages in Poona, Bombay, and the adjoining canal tracts, this is a distinctly low average. But when we turn to the agriculturists what do we find ? Apart from those who work outside the village there remain 76 men, 198 women, and 166 children (*i.e.*, under 16 years of age). Now assuming that out of these only 60 men, 120 women, and 40 children are capable of work, and that one man is equal to two women or children, this leaves 140 male units for the village. These earn Rs. 11,136 in the year, which works out at only Rs. 6-8-0 per mensem, assuming that they are working without any capital. But we are told that they are working with a capital of Rs. 93,588 (excluding houses). If we assume that they are content with 5 per cent. interest on working capital, this means that from agriculture each man is earning rather less than Rs. 4 per mensem. If on the other hand we take the rate of interest which in the Deccan is current for loans made on good security, *viz.*, 12 per cent., we find that the agriculturists are making absolutely nothing by their labour and

that they would be better off if they sold their land, cattle and implements, invested the proceeds and sat completely idle.

Now what is the meaning of the apparent paradox that the cultivators are content to earn little or nothing by their labour? It is susceptible of two explanations. One is that, in point of fact, the cultivators do earn more than is recorded, and the other is that they have such an easy time playing at cultivating a few acres that they will put up with a bare minimum subsistence for the sake of the ease secured. The true explanation is probably to be found partly in one hypothesis and partly in the other. It would appear very probable that apart from the 121 villagers who are recorded as working for wages outside the village, a certain number do occasional work of this nature and so supplement their earnings from agriculture, and also that in the off-season some money is earned by carting, apart from the four carts which are noted as plying for hire regularly. Further, in view of the fact that the average size of the farms is only 9 acres and that much of the cultivation given is of the poorest description, often consisting of nothing more than harrowing, drilling the seed, and reaping such crop as grows, it follows that the villagers who do no work except on their own land must have a very slack time. This brings us up against what is perhaps the most crucial problem for India. How much work does the average cultivator in any tract do? What is the efficiency of that labour? The hours of work and the efficiency of labour vary enormously from one tract to another, and the causes of this variation afford scope for the most interesting study. As regards this particular village it is clear that the standard of work and its efficiency are low. Out of the whole population there are only four men who can, even by courtesy, be placed outside the dead level of unskilled labourers, *viz.*, a gardener, a bricklayer, and two quarry-men; while the skill and energy of the cultivators may be judged from their unimproved lands, the poor out-turns of the crops, and the fact that they have to depend on outside labour to deal with a small area of sugarcane.

The final conclusion of the authors is depressing, for they maintain that two-thirds of the families in the village are unable

to attain to even the low standard of comfort which is considered essential by the people of such a village. To anyone who knows what such a standard is, this can mean nothing else than that there is actual starvation in the village, or something very like it. Surely this is a matter which would have admitted of actual verification on the spot ; but there is no word to show that any attempt was made, by observing the condition and health of the people, to verify this inference which the figures given so strongly suggest. The low standard of comfort in Deccan villages is deplorably evident even to the most casual observer, but if there is in this village anything like the actual starvation that is implied, this fact is more remarkable than any other which has been recorded ; because it may be stated with confidence that in this village there is no able-bodied family the members of which are prepared to work, which could not, without going 20 miles afield, obtain wages which would not only maintain them in comfort, according to their own standards, but which would also allow them to save money.

VETERINARY RESEARCH: SOME RECENT CONTRIBUTIONS.

In response to the suggestion made by the Board of Scientific Advice for India that *résumés* of such articles mentioned in the bibliography at the end of the Veterinary Section of its Annual Report as are likely to be of use to veterinary officers in the districts should be published half-yearly, Mr. A. L. Sheather, Director and First Bacteriologist, Muktesar Laboratories, has kindly undertaken to contribute such *résumés*. They will appear regularly in the January and July issues of this Journal.—[Editor.]

GLANDERS.

Lanfranchi, A.—The Intrapalpebral Mallein Test. *Il Moderno Zooiatro*, 1917, No. 9 (Ex. *Bull. L' Inst. Past.*, 1918, No. 2). Original not available.

Lanfranchi has tested a large number of animals by the injection of 2·5 c.c. of mallein subcutaneously into the lower eyelid. He has noted in a number of cases a condition of sclerosis of the lower eyelid, which has necessitated injecting the mallein into the upper lid.

In cases where the result is negative in horses which have been subjected to this method of testing on a number of occasions spread over an unknown period, it is advisable to wait a fortnight before carrying out a fresh test.

EPIZOOTIC LYMPHANGITIS.

Lanfranchi, A.—The Intrapalpebral Test in the Diagnosis of Epizootic Lymphangitis. *Il Moderno Zooiatro*, 1917, No. 10 (Ex. *Bull. L' Inst. Past.*, 1918, No. 2). Original not available.

As a general rule, the diagnosis of epizootic lymphangitis presents no difficulty. It may, however, be useful in atypical forms

of the disease to have at one's disposal an experimental method of diagnosis.

Lanfranchi has considered the possibility of applying to epizootic lymphangitis a method resembling the intrapalpebral test by means of which such good results have been obtained in the case of glanders.

The material injected is composed of one part of pus taken from an unruptured lesion and rich in cryptococci mixed with two parts of ether. The mixture is left for 24 hours. The ether is then evaporated off, and the volume made up again with distilled water. This suspension is heated over a water bath to 80° (whether centigrade or fahrenheit is not stated in the French abstract) for 20 minutes. After centrifuging, the supernatant liquid is drawn off. This constitutes the liquid for the test and the dose used is $2\frac{1}{2}$ to 3 c.c.

In infected animals the inoculation is followed at the fourth to the sixth hour by a hot diffuse œdema which increases up to the twenty-fourth hour, and sometimes persists until the fourth or fifth day. A purulent discharge collects, which is in some cases quite abundant.

In animals infected with diseases other than epizootic lymphangitis, the reaction is neither marked nor lasting.

The reaction is more severe in infected animals when the lesions are discrete and have not reached maturity. The local reaction is accompanied by a rise of temperature but no other evidence of systemic reaction.

A primary test does not prevent subsequent tests from being carried out.

A single animal has been successfully tested on six occasions (intervals not stated).

FINZI, G.—COMPOUNDS OF MERCURY IN THE TREATMENT OF EPIZOOTIC LYMPHANGITIS. *Bull. Soc. Path. Exot.*, Vol. X, No. 6, June, 1917.

The author has treated five severe cases of epizootic lymphangitis with mercurial compounds and has succeeded in effecting a cure in every instance.

The following formulæ and methods of application were used :—

(*a*) Six grammes of salicylate of mercury in 100 c.c. of sterile "vaseline oil."

1st day 10 c.c. injected intramuscularly.
4th ,, 10 c.c. ,, ,,
8th ,, 20 c.c. ,, ,,
12th ,, 30 c.c. ,, ,,
16th ,, 40 c.c. ,, ,,

and subsequently 5 to 7 more injections "of the same dose at the same interval."

(*b*) Five grammes of calomel in 100 of sterile "vaseline oil."

1st day 5 c.c. injected intramuscularly.
4th ,, 10 c.c. ,, ,,
8th ,, 15 c.c. ,, ,,
12th ,, 20 c.c. ,, ,,

and subsequently 6 to 8 injections at intervals of 3 days and in doses increased by 5 c.c. at each injection unless evidence of intolerance is observed.

(*c*) Perchloride of mercury 1 gramme, sodium chloride 2 grammes, boiled distilled water 100 c.c. This formula was used for hypodermic or intramuscular injection in the same manner as (*b*).

(*d*) Benzoate of mercury 1 gramme.
Sodium chloride 0·26 gramme.
Cacodylic acid 0·5 gramme.
Boiled distilled water 100 c.c.

1st day 20 c.c. hypodermically or intramuscularly.
4th ,, 20 c.c. ,, ,,
7th ,, 30 c.c. ,, ,,
11th ,, 30 c.c. ,, ,,
15th ,, 40 c.c. ,, ,,

and subsequently 5 to 7 further injections of the same dose at the same interval.

Attention is drawn to the fact that these formulæ must be used with care on account of individual susceptibilities to mercury and variations in absorption. If symptoms of mercurial poisoning are observed oily purgatives must be administered and an interval of 8 to 10 days allowed to elapse before the treatment is re-started. It was found necessary to suspend treatment only in the case of the animal treated with mercury salicylate.

All the animals are reported to have made complete recoveries after 10 to 12 injections. Formulæ (*c*) and (*d*) yielded the most rapid results.

BELIN, M.—THE TREATMENT OF EPIZOOTIC LYMPHANGITIS AND ULCERATIVE LYMPHANGITIS BY "AUTOPYOTHERAPY." *Rec. Méd. Vét.*, Vol. XCII, No. 18, 1917.

In a previous paper the author has published his observations upon the use of a vaccine prepared from pus from cases of epizootic lymphangitis by means of ether. In the present paper he refers again to this method of preparing the vaccine and also describes a method in which heating the pus with boiled water is the essential part. In preparing the vaccine by the ether method pus is collected with every precaution to ensure sterility and this is mixed with about four volumes of ether and shaken vigorously for a couple of minutes. After 18 to 24 hours a similar volume of boiled water is added and the vaccine is ready for use.

The second method of preparing the vaccine is to add to the pus six or seven times its volume of boiled water and to heat this at 70° for about an hour, 0·5 per cent. of carbolic acid being added subsequently. The latter method does not appear to have any advantages over the ether method, and the ether method is simpler to carry out.

The vaccines are said to keep well. Exactly the same procedures may be adopted for ulcerative lymphangitis.

Full details of fifteen cases treated are given.

The injection of the vaccine produces a more or less pronounced negative phase followed by a positive phase.

Although the author succeeded in obtaining cures solely by means of the vaccine, he does not propose to exclude other recognised beneficial treatments, such as evacuating abscesses, etc. His view is that the vaccine should be used in conjunction with such measures. The vaccines appear to vary somewhat in activity, but the author has never obtained an absolutely inactive one. Care must be exercised that pus from young lesions is used.

The injections of the vaccine lead to the formation of small local swellings which subside after a short time.

Successive doses may cause a slight induration which eventually disappears. In one case a small area of necrosis was observed. It is advised that a series of three or four injections of the vaccine in doses of 2 c.c. be first given daily and then a single dose of 2 c.c. weekly. The treatment is stopped when no negative phase is produced by the injection. Emphasis is laid on the importance of making the treatment autopyotherapeutic and not simply pyotherapeutic.

VELU, H.—LOCAL REACTIONS IN THE TREATMENT OF EPIZOOTIC LYMPHANGITIS BY PYOTHERAPY. *Réc. Méd. Vét.*, Vol. XCII, No. 20, 1917.

As a general rule, the injection of the first dose of vaccine produces only a slight œdema at the seat of inoculation which is quite insignificant when compared with the evidences of the negative phase shewn by the lesions.

In some cases, however, hot painful œdematous swellings which may either be absorbed slowly or develop into abscesses occur. Repeated injections may give rise to the formation of small abscesses from which a small quantity of thick creamy pus can be obtained by puncture. Such lesions heal under antiseptic treatment like ordinary wounds, provided they are widely opened. This intolerance increases with each injection. As a rule no organisms are discoverable in the pus, but in some cases cryptococci can be found. This was so in two healthy animals that were vaccinated as a protective measure. This shewed that two months' exposure to ether and

2·5 per cent. carbolised normal salt solution had not sterilized the pus. In such cases, however, the abscesses healed up well and shewed no tendency to develop into typical cases of the disease.

RINDERPEST.

BOYNTON, W. H.—EXPERIMENTS ON THE TREATMENT OF RINDERPEST WITH VARIOUS DRUGS. *Philippine Journal of Science*, Vol. XIII, Sec. B., No. 2, March, 1918.

The publication of the experiments recorded in this paper was considered advisable on account of the numerous claims that have been put forward by persons professing to have discovered cures for rinderpest.

It is noted that in those localities in which successful treatment has been claimed, the normal percentage of recoveries is very high, reaching in some cases 60 per cent. According to the author's general statement, the following twenty drugs have been used: eosin, medicinal methylene blue, cacodylate of soda, atoxyl, quinine sulphate, camphorated oil, creolin, permanganate of potash, ergot, iodine, potassium iodide, gentian violet, adrenalin hydrochloride, nuclein, formalin, chlorazene, castor oil, alcohol, fluid extract of nux vomica, and fluid extract of gentian.

Reference to the details of the experiments shows that in addition to these, salicylate of mercury and cannabis indica were also tried. A few experiments were carried out with anti-rinderpest serum, with a view to testing its curative properties.

In all, some fifty experiments were carried out, and it is stated that "with the small amount of experimentation that has been given to each drug, no promising results have been obtained by the method in which they were administered and the dosage in which they were given."

For intravenous and intraperitoneal injections 0·85 per cent. sodium chloride solution was used, and it was found to be advantageous to warm the solution to 41°C. before injection, the animal showing less discomfort than when cooler solutions were used.

Only two animals out of the whole series recovered, namely, one treated by intravenous injection of 1000 c.c. of 1 in 4000 of formalin, and one by intraperitoneal injection of quinine sulphate. Other animals treated by these methods died. The possibility therefore must be taken into consideration that these animals would have recovered in any case.

TUBERCULOSIS.

GLEN LISTON, W., and SOPARKAR, M. B.—THE SUSCEPTIBILITY OF INDIAN MILCH CATTLE TO TUBERCULOSIS. *Indian Journal of Medical Research*, Vol. V, No. 1, July 1917.

In the opening pages of this paper the authors summarize the references to the occurrence of tuberculosis among cattle in India, and contrast the degree of prevalence among them with the degree of prevalence among cattle in Europe. Attention is drawn to the fact that Indian cattle do not stand alone in showing a low percentage of infection with tuberculosis, a similar state of affairs existing in Japan, Ceylon, and the Malay Peninsula.

In seeking an explanation of the marked difference between the prevalence of the disease in cattle in India and elsewhere, the more open-air life spent by Indian cattle, which has been put forward as the main reason, is discounted to a very large extent when the low incidence of the disease among animals kept in sheds in large towns is taken into consideration.

The experiments detailed in the paper were undertaken with a view to ascertaining whether the relative freedom of Indian cattle from tuberculosis may be due either to natural immunity or to a relatively greater resistance than European or American cattle.

As it was impossible to control the experiments by the simultaneous inoculation of a parallel series of calves from European sources, the results obtained by the English Royal Commission on Tuberculosis in the inoculation of calves were taken as controls.

These experiments indicated that while the subcutaneous inoculation of 50 milligrammes of culture of bovine tubercle bacilli produced almost invariably a fatal generalized tuberculosis, a dose of 10 milligrammes, though often fatal, did not produce generalized disease.

As the bulk of the milk consumed in India is derived from buffaloes, these were subjected to experiment in addition to bovines.

Calves 4 to 8 months old were selected, because the effects of inoculations with tubercle bacilli are more severe in young animals than in adults.

In view of the rarity of tuberculosis among Indian cattle, the animals selected for experiment were not subjected to a preliminary tuberculin test.

The culture used was one received from Eastwood of the Local Government Board, England, in 1915. It was tested for virulence on receipt, and again after subculturing up to the date of the experiments by inoculation into rabbits. Intravenous inoculations of 0·1 and 0·01 milligramme produced fatal generalized tuberculosis in 22 and 25 days.

The culture used for the experiments was from glycerine agar, and it was emulsified in salt solution, so that each cubic centimetre of emulsion represented 5 mgms. of culture.

In the experiments, 11 buffalo calves and 12 bovine calves were inoculated. It was intended to inoculate 12 of each, and keep one of each as controls. Two of the buffaloes died prior to the experiment. One of these had been selected to act as control. One bovine calf was kept as a control.

Six buffalo calves and six bovine calves were inoculated with 50 milligrammes subcutaneously and the remaining animals with 10 milligrammes in the same way.

The clinical history, temperature charts, and *post-mortem* findings of each animal are given.

In summarizing the results obtained, a distinction is drawn on the lines laid down by the Royal Commission on Tuberculosis

between acute generalized tuberculosis and retrogressive tuberculosis, depending upon the extent and nature of the lesions found.

Of the buffaloes inoculated with 50 milligrammes, one died of broncho-pneumonia, apparently not due to the tubercle bacillus, three showed retrogressive tuberculosis at the time of death or slaughter, and the remaining two showed acute generalized tuberculosis.

Of those inoculated with 10 milligrammes, one died of broncho-pneumonia, two of diseases other than tuberculosis, and the remaining two showed lesions of retrogressive tuberculosis.

Of the bovine calves none died of intercurrent diseases. Of those inoculated with 50 milligrammes, three showed acute generalized tuberculosis and three retrogressive tuberculosis. Of those inoculated with 10 milligrammes, three showed acute generalized tuberculosis and three retrogressive tuberculosis.

Apart from the extent and nature of the lesions produced by the inoculations, attention is drawn to the duration of life of the animals after inoculation, this being contrasted with the periods of life of the animal selected from those used by the Royal Commission on Tuberculosis which were taken as controls.

The Royal Commission calves inoculated with 50 mgms. of tubercle bacilli subcutaneously died, or were killed when dying at periods ranging from 18 to 76 days; only one surviving to this maximum, the remainder dying within 47 days.

In the experiments recorded in the present paper the following periods of life were observed in animals inoculated with 50 mgms. Two buffaloes died of acute generalized tuberculosis after 67 and 101 days; three were killed after 125, 128, and 142 days and showed retrogressive lesions only. These three animals had all gained in weight during the experiment. Of the bovine calves, three died of acute generalized tuberculosis in 38, 39, and 43 days. The remaining three inoculated with 50 mgms. were killed after 122, 122, and 142 days and showed only retrogressive lesions in *post-mortem*.

Graphic charts are given showing the distribution of the lesions in each of the experimental calves and corresponding calf selected from the Report of the Royal Commission on Tuberculosis. From the experiments the following conclusions are drawn :—

The comparative infrequency of tuberculosis among Indian cattle, whether buffaloes or bovines, is due to a natural resistance to infection rather than to differences in methods of housing, etc.

In view of the fact that some of the Indian calves inoculated even with 10 mgms. of culture died as quickly from generalized tuberculosis as English calves, it would appear that individual susceptibility varies more among Indian than among English cattle.

The question as to whether variation of susceptibility varies with breed has not been attacked.

Less frequent opportunities of acquiring infection plays a part in the comparative rarity of the disease among Indian animals.

Attention is drawn to the danger to indigenous herds resulting from the possible existence of tuberculosis among imported animals. Further attention is drawn to the fact that the subcutaneous injection of 50 mgms. of culture of tubercle bacilli into Indian cattle does not furnish a criterion as to whether the bacilli injected are of human or bovine origin. The result of such an injection into European or American animals is considered a crucial test of the type of bacilli used.

The experiments throw some light upon the practical absence of lesions due to the bovine type of bacilli in human beings in India.

TAYLOR, G.—NOTE ON THE PREVALENCE OF BOVINE TUBERCULOSIS IN THE PUNJAB. *Indian Journal of Medical Research*, Vol. V, No. 3, January, 1918.

In this paper the author gives details and a tabular statement of his findings in the course of an inquiry extending from August, 1915, to March, 1916.

During this period 3,276 animals were brought to Ferozepore for slaughter. Practically the whole of them came from Central and South-Eastern Punjab, and all were of the indigenous breed. The system of inspection entails examination prior to and subsequent to slaughter, and only those found to be apparently in health and in good condition while alive are allowed to be killed for subsequent inspection.

It is pointed out that 17·8 per cent. of the total number were rejected for various reasons while alive. In view of the fact that the greater number of them were rejected for innutrition—a condition most frequently associated with chronic tuberculosis—it appears to be probable that of the animals rejected prior to slaughter a considerable number were tuberculous.

Attention is further drawn to the fact that carefully selected stock were dealt with, a point which must be borne in mind when the possible prevalence of tuberculosis among cattle in general is being considered.

In all, 95 animals were found to have lesions which, to the naked eye, appeared to be tuberculous. The fact that the whole of the cases were found to occur in females is not evidence of sex incidence, as practically the whole of the beef is derived from cows and heifers. In all cases but two the lesions were confined to the thoracic cavity—the bronchial and mediastinal glands alone or together with the lungs. In one of the exceptional cases there was tuberculosis of the mesenteric glands, and in the other extensive disease including tuberculosis of the udder. Tubercle bacilli were found by microscopic examination in 60 out of 95 cases, but it appears to be probable that this proportion is too low, bacilli having escaped detection in some instances.

During the year 1916-17, 4,610 animals were brought for slaughter, of which 17·8 per cent. were rejected as unfit for slaughter. Of the remaining 3,789, 3·3 per cent. were found to be infected.

These figures would appear to indicate that, at least as far as concerns the Punjab, tuberculosis is not as rare a disease among Indian cattle as has been thought.

It is pointed out that up to the present all the cases of bovine tuberculosis in Indian cattle have been recorded in Northern Provinces. On the other hand, the absence of or the limited nature of inspection in other parts may explain to some extent the absence of records of the disease.

HELMINTHIASIS.

LANE, CLAYTON.—ANCYLOSTOMA DUODENALE AS A PARASITE OF FELIS TIGRIS. *Indian Journal of Medical Research*, Vol. V, No. 1, July, 1917.

The author gives a description of the finding of five specimens (four female and one male) in the jejunum of a tiger, and establishes beyond doubt the fact that the worms found must have been actual parasites of the animal.

Figures are given showing the parts upon which the identification was based, and attention is drawn to the fact that, though the worms were somewhat smaller than those found in man, the question of size alone cannot be held to justify the view that the parasites were not actually specimens of *Ancylostoma duodenale.*

This discovery is held to make no material difference to the measures necessary to prevent the infection of man; but it definitely establishes the fact that man is not the sole host of the worm.

CONTAGIOUS ABORTION.

MCFADYEAN, J., and EDWARDS, J. T.—CONTAGIOUS ABORTION IN MARES AND JOINT-ILL IN FOALS—ETIOLOGY AND SERUM TREATMENT. *Journal Comp. Path. and Therap.*, Vol. XXX, No. 4, December, 1917.

Before detailing the results of their own experiments which were begun in April, 1916, the authors give a valuable review of the research work that has been carried out by other investigators.

At the outset the authors state that the organism which they have isolated is identical with that found by De Jong, Good and

Corbett, and which has been named by the latter *Bacillus abortivo-equinus*.

In view of this fact a detailed description of the bacillus is not given. Photographs shew the appearance of the bacillus under the microscope and the characteristic appearance of the growth on the surface of agar.

It is pointed out that while the immense majority of the organisms are short or ovoid the bacillus is pleomorphic and distinctly longer bacilli are not infrequently found both in infected materials and in artificial cultures.

The most important characteristic feature of the organism for the purpose of identification is the form of growth that develops on agar.

The authors' on description of this may be quoted: "Although previous authors have generally referred to this surface irregularity as a 'wrinkling' the word does not very accurately describe the appearance, as close inspection shews that it depends upon the development of intersecting ridges by which the otherwise flat surface is divided into a series of spaces. These spaces vary in size and shape, but nevertheless form a comparatively regular pattern, which, when the spaces are largest, recalls the appearance in miniature of tanned alligator or lizard skin. Within some of the spaces a very much finer pattern, resembling finger prints, is seen.

"This appearance is not always obtained, especially if the growth be meagre, but it is present when abundant and rapid multiplication of the bacillus occurs."

The authors have isolated this bacillus from ten foals in all. The first two animals were foals born dead a month before full term. The bacillus was recovered in pure culture from the heart blood, liver, stomach, and intestines.

The eight other animals were foals born dead or dead of joint-ill. From all these animals the organism was cultivated from the heart blood, liver, spleen, and other organs, and in the foals born dead from the stomach and intestines also.

In six instances it was cultivated from the liquid in one or several joints and it was noted that three of these foals were born dead and shewed no evidence of joint disease.

Two of the ten animals from which the cultures obtained were not pure at the outset were foals that had died of joint-ill. One of the foals developed joint-ill three weeks after birth and died a few days later. While cultures from the pleural, pericardial, and peritoneal fluids, kidney, a stifle and an elbow joint were pure, those from the heart blood, mesenteric glands, spleen, liver, lungs, and a hock joint shewed also streptococci. A similar contaminating organism was found to be present in small numbers in some of the cultures made from the second case.

The identity of the organism in all cases was settled by cross-agglutination tests.

The authors detail the evidence available upon the question as to whether the bacillus isolated is the cause of abortion and joint-ill, and their conclusion is:—"For these different reasons it appeared to us that it was justifiable to accept the bacillus as an actual cause, and probably the commonest cause both of outbreaks of abortion in mares and of joint-ill in foals.

Having established this fact the authors proceeded to carry out experiments in connection with the production of a protective serum. For this purpose three horses were inoculated intravenously or subcutaneously at intervals during a period of three or four months.

The serum from these horses was tested by agglutination, and it was not issued unless a dilution of at least 1 in 5,000 produced complete agglutination.

The dose was fixed at 50 c.c. for a foal and it was advised that a second dose should be given after a week if improvement was not observed.

The serum was issued free to veterinary surgeons on condition that it was used solely for foals suffering from joint-ill, that no other treatment was resorted to, and that the results were reported.

than 4 cents per pound. It is improbable that any arrangement could be made for the United States Government to use the Haber process pending the conclusion of the European war. It is probable that, when the war is ended, the Haber process will be installed, or will be available for installation, in the United States. It is the cheapest process for the production of synthetic ammonia. It is independent of cheap power—the power being a small fraction of its cost. If desirable, it could be readily installed in moderate-sized units in connection with ammonia oxidizing plants at any munitions plant.

Cyanamide Process.

The cyanamide process has been developed in many parts of Europe, but in the Western Hemisphere only at Niagara Falls, Ontario, Canada. It requires cheap power for its successful operation, and has obtained its greatest development owing to the fact that it requires only about one-fifth the horse-power per ton of fixed nitrogen per year that is required by the arc process.

Ammonia from cyanamide, with power at $8 per horse-power year in a plant to be constructed by the Government, would cost 1 to 2 cents per pound more than by the Haber process. On the other hand, royalties for using the cyanamide process would undoubtedly be less. The technical problems involved are understood by many engineers both in this country and abroad, the manufacture of calcium carbide and cyanamide being established in many plants, and the basic patents having only some four years more to run. Peculiarly favourable conditions exist for its installation in certain sections of the South. If a hydro-electric plant is to be installed by the United States Government, and the electrical power so developed be used for the fixation of nitrogen, the cyanamide process has advantages over all other processes now developed, and should be adopted as the best means of utilizing hydro-electric power for the fixation of nitrogen.

In Germany, in 1913, there were produced 30,000 tons of cyanamide. The growth has not been so rapid as in the case of the Haber process, although the process has been subsidised by

the German Government to assist in its development. However, the 1917 German production will be not far from 400,000 tons. The cyanamide interests in Germany have also endeavoured to induce the German Government to establish a nitrogen monopoly which will insure the continuation of the cyanamide industry in Germany in competition with the Haber process and ammonium sulphate from coke ovens after the war. Cyanamide has not found favour with American fertilizer manufacturers, and is not well suited as an addition to the mixed fertilizer demanded by American farmers. It is, however, successfully used in Europe where labour is much cheaper. To meet the Government's requirements of 20,000 tons and 180,000 tons of nitric acid through the medium of cyanamide would require the continuous use of 11,000 horse-power and 99,000 horse-power respectively.

If cyanamide is to be converted into the most popular form of fertilizer material, namely, ammonium sulphate, it would cost approximately 1 cent per pound to convert the nitrogen present into the form of ammonia before it could be absorbed to form sulphate. It is the necessity of converting the combined nitrogen into ammonia, if the cyanamide process is used as a source of nitric acid, that makes up a considerable portion of the difference in cost between cyanamide ammonia and Haber ammonia.

By-Product Ammonia.

In the United States less than one-tenth of the bituminous coal burned is coked in by-product ovens. Of the coke produced in America, over one-half is still produced in beehive ovens in which the gas, ammonia, and all other by-products are ruthlessly destroyed. There has been nevertheless a rapid increase in the installation and operation of by-product ovens, and an increase in ammonia production that would not have been thought possible two years ago. By the end of the present year we will be producing at least 115,000 tons of ammonia per annum—an equivalent of 450,000 tons of ammonium sulphate. Six thousand tons of this ammonia in time of peace, or 55,000 tons in time of war, would meet the nation's requirements of nitric acid for military purposes, as estimated by

the War Department. The growth of our ammonia production from by-product coking has been extremely rapid, and is still on the increase. More than fifty million dollars' worth of by-product coke ovens have been contracted for within the past twelve or thirteen months, and are now completed or in process of erection.

The general use of coke instead of coal throughout the United States would produce, besides other by-products, approximately 1,000,000 tons of ammonia. The day is far off before this highly desirable result will be reached, but it should none the less be striven for. Already legislation abroad requires the use of coke instead of bituminous coal for certain industrial purposes. By-product coke ovens, however, cannot be installed by the United States Government for the purpose of producing ammonia. The ammonia should be simply a by-product incidental to the production of coke for industrial purposes. Under war conditions, however, the output of ammonia from by-product coke ovens could, by Government regulation, be greatly increased. This has been accomplished in Germany, the by-product coke ovens furnishing Germany to-day with over one-third of the nitrogen consumed in that country. Germany has had an increase from 100,000 tons to 154,000 tons of nitrogen from this source since the war began. The possibilities for an increase in America are much greater than in Germany.

Ammonia from by-product ovens has to be purified before it can be oxidized to nitric acid. The cost of purification is, however, very small, and, where purification apparatus is installed at the original ammonia absorption plant, adds but a small fraction of a cent a pound to the cost of crude ammonia liquor.

The use of by-product ammonia for the production of nitric acid for munitions purposes has the great advantage that it is already available, and that the plants, being situated in numerous parts of the country, could furnish ammonia to several small oxidizing plants. Accordingly, the country's source of munitions supply would not be at any one place and subject to capture and destruction.

The use of by-product ammonia has the great disadvantage that the present selling price of ammonia from by-product coke

is high, and unless considerable price concessions could be obtained by the Government, it could not afford to utilize this source of raw material for nitric acid. The actual cost of pure ammonia considered as a by-product from the coking of bituminous coal is much less than by any other method now producing this substance.

Cyanide Process.

The cyanide process is not yet a commercial success, but it has great possibilities. There is no difficulty whatever in the chemical reactions. No power factor of any consequence is involved, and it appears certain that if the mechanical difficulties are solved, nitrogen will be fixed in this form cheaper than by any other known synthetic process. There are also large quantities of waste nitrogen available in connection with the sodium carbonate plants of the country, where the sodium carbonate required would also be available, and there are large amounts of nitrogen that could be obtained without cost in a sufficiently pure condition at the wood-pulp plants using the sulphite process.

When the sodium cyanide is once formed, it can be readily converted into ammonia, as is the case with cyanamide; but the process has the advantage that in the conversion the sodium carbonate can be recovered to be used over again. The iron can also be repeatedly used in the process. Small installations are now working successfully in the country, but the mechanical difficulties of production on a large scale are yet to be solved. Four large American corporations are engaged on the problem with ample funds for its solution.

The process has the further advantage that it would also make cheaply available cyanide which is so greatly needed by our mining industries.

Nitric Acid from Ammonia.

All processes for the synthetic production of nitric acid, except the arc process, involve the oxidation of ammonia. The processes commercially in use involve the direct oxidation of ammonia gas in the presence of air in contact with metallic platinum. In Germany,

according to the latest published figures, approximately 100,000 tons of nitric acid are annually produced through the Frank-Caro process which involves passing mixtures of ammonia and air through electrically heated platinum nets of 80 to 100 mesh. The platinum is heated to a dull red heat, and serves as a catalytic agent under whose influence the ammonia, instead of burning to nitrogen and water as normally would be the case, is oxidized to nitric oxide.

In the Kaiser process, also used in Germany, the air is heated before its mixture with the ammonia, and under these conditions it is claimed that no electric heating of the platinum net is necessary. The Kaiser process does not appear to have reached any large commercial development.

In the Landis process, installed in a small experimental plant at Warners, N. J., the gas is passed downwards through the net instead of upwards as is customary in the Frank-Caro process, and according to the Landis patents, the gases are cooled before they are allowed to come in contact with the net instead of being heated as in the Kaiser process. The platinum-net process is also understood to be installed in a small plant in Long Island City, and is being installed in Syracuse, N. Y., by the Semet-Solvay Company in co-operation with the Bureau of Mines.

The Ostwald-Barton process, first developed at Villevorde, Belgium, and brought there to a commercial success at the time of the opening of the war, is now installed in two large plants—one at Angouleme, France, and the other at Dagenham, England. The principle of the process is essentially that originally patented by Ostwald, but the catalyser is distinctly different from that used by him, although it consists of metallic platinum. The details of the preparation of this catalyser are kept secret, but it is known to have a very small cross-section and is placed at the end of a 60-mm. tube, so that the products of combustion passing through the tube heat the mixed ammonia and air by radiation as they approach the catalyser. By this means no external heat is necessary. The reaction when once started continues without interruption for weeks. It is simply necessary, by means of blowers, to force the mixture of ammonia and air through

the catalyser. The present commercial efficiency and output by the Ostwald-Barton process is higher than by any other concerning which exact figures have been obtained. It is higher than the published figures for the Frank-Caro process, but as figures for that process have been published only on a minimum basis, it is impossible to state whether as high an efficiency of conversion and capacity of catalyser has been reached by that process as by the Ostwald-Barton.

The processes for the oxidation of ammonia are seemingly free from any complicated patent situation. The Europeans engaged in ammonia oxidation admit freely that they have no important patent rights to sell, but they claim that they have plans, specifications, and details of processes, the purchase of which would be cheaper than the necessary experimentation to work out the details.

By the oxidation of ammonia, nitric oxide gases are obtained of much higher concentration than those produced by the arc process. Accordingly much less tower space is necessary for their absorption, and much stronger acid can be directly obtained by concentration. Although in the arc process the concentration of 30 to 35 per cent. nitric acid to strong acid is required, in the oxidation process an acid of 50 to 55 per cent. strength is easily obtained directly from the towers, and the concentration thereof is accordingly a simpler matter.

A method has been developed in Sweden, details of which are unknown, for the oxidation of ammonia or cyanamide direct to ammonium nitrate in solution. Plants have been erected near Gothenburg, Sweden, and near Berlin, Germany. It is claimed that this process will produce ammonium nitrate much cheaper than any other.

The Nitrogen Situation.

In view of the fact that Germany has invested millions of dollars in synthetic nitrogen plants which will continue to produce nitrogen compounds after the war; that Germany is producing more than twice the amount of combined nitrogen that she formerly imported in the form of Chilian saltpetre; that accordingly the

German market for Chilian saltpetre will be essentially non-existent after the war; that the present large American and Allied consumption for munitions will cease; and that during the war the American production of ammonia from by-product coke ovens has increased to a point in excess of our apparent normal consumption, it seems certain that the price of combined nitrogen for industrial and agricultural purposes must greatly decrease when the war is over.

It is evident at once that the peace-time requirements of the Government for nitric acid could be supplied from coal-tar ammonia with little effect on the market for the material and practically no effect on the country's nitrogen resources. It seems equally certain that in the case of war by-product ammonia could furnish 180,000 tons of nitric acid per year for at least one or two years without seriously affecting the nation's agriculture.

This is particularly important when it is remembered that over 60 per cent. of the nitrogenous material used in fertilizer, consisting of organic nitrogen from cotton seed meal, tankage, dried blood, etc., would not be decreased at all but would rather be increased through the cutting off of exports of cotton seed meal.

Furthermore, it is well known that several of our largest corporations are engaged in active plans for installing synthetic nitrogen plants of various kinds to meet their own industrial requirements, and that in all probability the Haber process will enter into active industrial competition for our ammonia markets in American plants as soon as the war is over. Plants for the oxidation of ammonia can be quickly erected in crude form, as they were erected and utilized in Germany, should the need arise.

I accordingly feel that no serious emergency problem confronts the United States that could not be met with reasonable celerity in time of war, and that our first problem, after securing a reasonable reserve of Chilian saltpetre, is to familiarize ourselves with the most efficient method for the oxidation of ammonia and to train the necessary men to construct and operate ammonia oxidation plants.

Cost of Nitric Acid.

The cost of nitric acid, *per se*, whether as weak nitric acid or as concentrated nitric acid, is lowest by the arc process with hydro-electric power delivered to the furnace at a cost of $10 per horse-power year, or less. The difficulties of its transportation, the large amount of power required, and other economic reasons, as already explained, make the arc process inapplicable to American conditions.

The cost of nitric acid obtained by the oxidation of pure ammonia is independent of the source of the ammonia, and must therefore depend upon the cost of ammonia gas in the gasholders ready to be passed to the oxidizing apparatus.

Cost of Ammonia.

The cost of ammonia has at the present time no relation to its selling price. The actual cost of collecting, absorbing, and purifying ammonia from the gases developed by the destructive distillation of bituminous coal, in other words, the cost of ammonia considered as a by-product, is less than by any other process. The selling price of by-product ammonia is entirely a question of competition with other nitrogenous products, and has been fixed in the past almost wholly by the market price of sodium nitrate with which it enters into competition. Even should ammonia be placed on the market by the Haber process at a price as low as 4 cents per pound, by-product ammonia will still be sold in competition therewith at a profit to the producer. The Haber process can produce, and is producing, ammonia synthetically cheaper than any other synthetic process now industrially applied. The cyanamide process stands next in order.

If mechanical difficulties now confronting the cyanide process are solved, it will produce ammonia cheaper than either the Haber or the cyanamide process, and in close competition with the actual costs of saving by-product ammonia. The details of costs by all of the above methods will be considered in the final report.

Summary of Conclusions.

(I) The Government should obtain its nitric acid by the oxidation of ammonia. It should begin the erection of an ammonia-oxidation plant of moderate capacity at an early date in order to train men and obtain experience in the most efficient method of procedure.

(II) The Government should proceed slowly in the matter of the erection of plants for the production of ammonia, as developments in the cyanide process and the availability of the Haber process may render valueless within a short time any large expenditure for the production of cyanamide. This is doubly true in view of the fact that present appropriations are not nearly sufficient to install water power and erect the nitrogen fixation plants necessary to meet the Government requirements as estimated by the Ordnance Department. The adoption of the above procedure involves :—

1. Purchase by the Government of a reserve supply of sodium nitrate of at least 200,000 tons.
2. The purchase of ammonia on the open market.
3. The reservation of a supply of platinum.
4. The construction of a hydro-electric plant only if the arc or cyanamide process is to be used. The oxidation of ammonia requires very little power, and the Haber, cyanide, and by-product ammonia processes are all independent of cheap power cost. The development of water power, however, cannot but be of benefit to the country even if it is not used for the fixation of nitrogen.

I seriously doubt whether hydro-electric power will be necessary or desirable three years from now for the most efficient process of fixing nitrogen, and accordingly I deem it unwise to install such hydro-electric power, at great cost, with the sole purpose of fixing nitrogen. If, however, such water power can be utilized by the Government in the production of certain ferro alloys absolutely essential for ordnance and other munitions ; can be sold to commercial companies who will take upon themselves the financial risk involved in the erection of plants for nitrogen fixation, under guarantee of cheap ammonia to the Government ; or can be sold

during peace times to companies requiring power for purposes which would allow instant requisition of the power by the Government in time of war without handicapping the supplies of other needed war material, the development of such hydro-electric power would be highly desirable.

The first and third recommendations have already been adopted, and are progressing towards fulfilment.

In a supplementary report, dated April 30th last, Dr. Parsons states that a small plant for the oxidation of ammonia erected at Syracuse, N. Y., is progressing successfully; another experimental oxidation plant at Laurel Hill, L. I., has developed other new features. At Syracuse two new forms of apparatus for the oxidation of ammonia are now being tried, one of which, if successful, will do away entirely with the use of platinum in the production of nitric acid.

Development has been rapid during the last two months. A synthetic ammonia process and a cyanide process have now reached a state of development where I am prepared to recommend definite action by the Government.

General Chemical Company Process.

During the past four years the General Chemical Company, working on the basis that it should be possible to develop conditions under which the synthetic production of ammonia by the direct combination of nitrogen and hydrogen should take place at lower pressures than those deemed necessary by the Haber patents, has achieved success. This process has been in successful operation on a large experimental scale with several small units for ammonia production, and one unit larger than those supposed to be used in Germany. The General Chemical Company has also developed and brought to a commercial basis the production of a mixture of nitrogen and hydrogen from coke, air, and water which will yield hydrogen at a cost lower than heretofore obtained in this country, and probably lower than that obtained in Germany. Complete engineering plans have been prepared and bids obtained on the main items of construction, so that the erection of a plant for the

synthetic production of ammonia can be proceeded with without delay. The Company itself would have already had a plant in operation save for the present high construction costs and other difficulties incident to operations at the present time.

The General Chemical Company has offered the free use of its process to the Government, and the full help of the Company in installing and operating the process.

It is estimated—I believe conservatively—that even under present conditions a 30-ton-per-day plant can be built for an expenditure of $3,000,000, and can be operated at a cost of not to exceed 4 cents per pound of ammonia produced, allowing $5·00 per ton of product for repairs, and 12½ per cent. of the cost of the plant for interest and depreciation. It is believed that the charges for repairs, interest, and depreciation are excessive, as together they comprise more than 50 per cent. of the total cost of the ammonia production. In the estimates $3·00 per ton of product is allowed for general expenses and overhead charges.

It is estimated that a smaller plant of at least 7½ tons per day capacity can be built at the present time for approximately $1,100,000, including land and building. Such a plant would yield 2,700 tons of ammonia per year—equivalent to 8,700 tons of 96 per cent. nitric acid, assuming 85 per cent. recovery. Such a plant would require about 500 horse-power.

I recommend that an initial plant to produce 60,000 lb. of ammonia per day be immediately constructed, and to this end I recommend that the War Department set aside the sum of $3,500,000, and that the initial plant be constructed at some point to be selected by the War Department in South-West Virginia, or adjoining territory in West Virginia, reasonably near to the sulphur, sulphuric acid, and coal supplies of that region, and so situated near to plenty of good water that an ammonia oxidation plant and a powder plant may later be erected near by.

Cyanide Process.

The cyanide process, too, has greatly developed in the last few months.

The President of the Nitrogen Products Company considers the process a certain commercial success, and a probable competitor with any other process for the production of fixed nitrogen. The Company is operating two experimental plants by the cyanide process—one at Saltville, Va., in a coal-fired furnace, and one at Niagara Falls in an electric furnace.

After careful examination of this process, I am not convinced that it has yet reached a point when plant installation should begin, as I believe a few months' experimentation will add greatly to the efficiency of the furnace proposed. It is my belief, however, that the process will become an important factor in the world's nitrogen market; that it may become a strong competitor even of other processes on account of the simplicity of its operations and the low cost of plant construction; and that a furnace, which I believe I see in embryo, can be developed which will be much more efficient than either of those now used.

The process is so promising that I recommend that active experimentation on a large scale be conducted, that a sum not to exceed $200,000 be set aside for this purpose. With this amount available, I feel confident that this process can be put upon a commercial basis; that it will become a real competitor in the production of ammonia for nitric acid and of nitrogenous material for fertilizer.

Estimates of Construction and Operating Costs.

In order that the recommendations made above may be considered in comparison with the older processes now operating on a large scale, I submit herewith a table summarizing confidential data obtained from books of many companies bearing upon the cost of nitrogen production.

Data per ton of nitrogen—by the Arc, Cyanamide, Haber, and General Chemical Company Processes.

	Arc	Cyanamide	Haber	Gen. Chem.*
Product	35%HNO_3	NH_3	NH_3	NH_3
Power required	10·5	2·2	0·2	0·2
Investment	$1410(a)	$440(a)	$340	$300
Operating costs†	170	150(b)	119	97
Product	96%HNO_3	96%HNO_3	96%HNO_3	96%HNO_3
Power	10·8	2·3	0·3	0·3
Investment‡	$1550	$670	$570	$530
Operating costs§	220	270	239	217

* Estimates on General Chemical Co. process are based on present war-time construction costs. All others on normal prices.

† Amortisation for cyanamide as charged by operating companies. Amortisation for Haber, 20% of plant cost for repairs, interest, depreciation. Amortisation for Arc and Modified Haber, 12½% interest and depreciation. $5 00 per ton of product for repairs.

‡ Except for Arc process, includes ammonia plant as given ; power additional $10 ; oxidation, and absorption, $140 ; concentration $40 ; steam plant $40.

§ Except for Arc process, includes ammonia costs as given ; oxidation $50 ; concentration $70. No allowance made for unoxidized ammonia.

(*a*) Power plant investment reckoned at $100 per horse-power.

(*b*) Cyanamide production $122, ammonia from cyanamide $28, total $150.

A TEXTILE SUBSTITUTE: EXPERIMENT WITH NETTLE FIBRE. *

STINGING nettle fibre as raw material for the textile industry is in use in a varying degree in Germany, Austria, Denmark, and Switzerland. Originally intended as a substitute, its use has been pressed forward in the Central Empires through the shortage of cotton caused by the war.

THE GERMAN CLAIMS.

The danger of ignoring a substitute is the possibility that by scientific experiments and research it may become a serious competitor with staple industries, before the full extent of the risk has been appreciated. Believing this to be the case with the stinging nettle, and hoping to seize an opportunity of making Germany independent of supplies of foreign cotton, the Germans have studied, tested, and adopted it as a war necessity ; there is evidence available showing that they also claim to have discovered a new process for its utilization, which opens up a great future for the industry even after the war. Large quantities of nettles were collected in the summer of 1916 (according to one authority) under the supervision of the 'Nesselfaserverwertungsgeselischaft,' the new German War Company, holding an exclusive right to purchase, if necessary by compulsion, all stems of stinging nettles (*Urtica Diocia*), whether native or imported. This company claimed that a tissue, comparing favourably with that manufactured from American cotton, was obtained from the fibre. Mixed with wool, a cloth of soft texture, hardly distinguishable from expensive woollen material, much cheaper and easily dyed, is said to be produceable, the cloth being suitable

* Reprinted from the *Board of Trade Journal and Commercial Gazette*, London, dated 3rd January, 1918.

for use in the manufacture of furniture covers, plush and suitings. There is, however, no confirmation of this claim, although there is no doubt that the fibre has been used to make linings for caps, coats, etc., for sandbags and probably for Army shirts and towels.

An Adverse Report.

Before describing the method of cultivating and preparing the fibre, an adverse report on its possibilities should be noted, for it shows that some doubts exist concerning the future of nettle fibre even in Germany. A German agricultural expert states that the cost of production rules it out for purposes of cultivation, and will stand in the way of its general adoption, notwithstanding the fact that its cultivation is now a national necessity. In the first place, the only soil available is so-called fallow land—all other land being devoted to more profitable use—and the cultivation of this land demands an immense amount of labour such as no farmer in the Central Empires can afford without special aid. Not only must the land be ploughed, but each plant has to be placed into the ground separately, because the nettle, when cultivated, either loses its power of propagation by seed, or produces such a weak crop that it becomes of little use for fibre. This intensity of labour is required at the very time when farmers are engaged in preparing more valuable crops. The results of this authority's experiments in the use of the fibre in place of cotton were poor in the extreme, and he came to the conclusion that, while it is hopeless to look to farmers for an adequate supply of nettles, something might be done to stimulate the natural growth of the nettles on their natural soil by assisting the spreading of seeds, or by using prisoners of war for the cultivation of waste lands.

Cultivation in Germany.

The present cultivation in Germany is entrusted to a company established by men from the textile industry and agriculture, which is supervised by the Ministries of War and Agriculture. This company supplies plants and money free of interest to cultivators. The nettle is propagated by slips and from seed. The slips develop

more rapidly than the seedlings, but in shady woodlands seedlings grow even in the first year into strong plants, from which a crop can be gathered in October. Slips can be set in the spring and the autumn; seeds in the spring only. For slips the harvest may be two-fold—in July or August for the stems; in October for fodder.

German and Austrian authorities estimate that a sufficient area of land is available within the Central Empires to meet their needs and to permit of a large export trade. According to the Association for Forwarding Trade Activity (Berlin) the yearly raw material available from a plant yielding a quite practicable fibre which can be used as a substitute for cotton and jute (and which is presumably the stinging nettle), can be reckoned at 6,000,000 metric tons. In this connection it may be noted that in 1913 Germany imported 447,945 tons of raw cotton and 162,063 tons of jute.

By a Bundesrat Order of 27th July, 1916, the War Nettle Company fixed the price of stinging nettles for fibre at 14 marks per 100 kilogs. Subsequent evidence indicates that this rate is being paid for it, and that dried stinging nettle leaves, utilized for fodder and medicinal purposes, fetch 25 marks per 100 kilogs. The yield of fibre, again, varies from 10 per cent. in the case of wild nettles to as much as 30 per cent. in the cultivated plant.

Preparation of the Fibre.

In the method of preparation for spinning, which is adjudged best by the Royal Materials Testing Office, only nettles cut just above the ground are utilized. They are packed in bundles, dried, and the leaves removed. The stripping is satisfactorily done by the use of a lath set with nails in the form of a comb through which the stems are drawn lengthwise. After stripping, the stems are bundled. An Austrian manufacturer declares that a process of obtaining the fibre, devised by Dr. Richter of Vienna University, by steeping and roasting the stems, yields fibre which should take the place of flax, hemp, and of cotton. Dr. Richter's process appears to be carried out at ten factories in Bavaria, Silesia, and Alsace—that is, six rope factories, three jute factories, and a cotton-spinning mill.

The complaint against the process is that it is unsuitable for the production of the finer spinning stuffs, as it does not remove the wood from the fibre. A newer process, however, appears to have been discovered giving better results, and a great future is anticipated for the product.

Special machines have been built to deal with the fibre in the weaving industry. Several qualities of the stuff have been obtained by adding a suitable quantity of flax to the fibre. Moist-spun yarn up to No. 14 and dry-spun yarn up to No. 6, have been produced in large quantities in several factories.

Danish Experiments.

In spite of these somewhat optimistic opinions, it must be repeated that there is no clear evidence of the extensive adoption of the nettle fibre, even under present conditions, in Germany. Nevertheless the following independent and reliable account of Danish experiments confirms the view that the stinging nettle, as in Hans Andersen's tale of Elfride, may at any moment be convertible into shirts, and on a considerable scale.

In Denmark a Government Committee experimented with nettles, paying for them at the rate of 7 kr. per 100 kilogs. For textiles only the fibrous part of the plants is necessary, and of the three known methods of separating this from the rest of the nettle—the mechanical, the chemical, and putrefaction—the last-named is the one favoured by the Committee.

Methods of Treatment.

The treatment resembles the treatment of flax, and the main points of the method are :—

(i) The nettles are harvested in September and October and stacked like straw through the winter.

(ii) The tops and leaves are removed.

(iii) The stalks are rotted either (*a*) in a "retting dam" consisting of a wooden cage sunk in a lake or other natural water, or (*b*) in hot water. The former process takes fourteen and the latter four days with the water at a temperature of 30 degrees

centigrade. Experiments are still continuing to define the correct heat and time.

(iv) The stalks are dried in the open air.

(v) The stalks are cracked in a breaker.

(vi) The stalks are teased on a teasing board with a wooden knife.

(vii) The fibre is combed through a large iron comb or hackle, which finally removes all the remaining wood.

The fibre is then ready for the rope-walk or the spinning wheel.

One of the difficulties of the putrefaction process is the presence of bacteria. It has been discovered that there are two sorts prevalent—a beneficial and a harmful. It is said that the harmful species can be removed by steeping the nettles in running water for two to five hours before commencing to treat them. Experiments are being conducted in the pure cultivation of these bacteria with a view to finding a simpler method of putrefaction.

The Manufactured Article.

It has been found possible to make from nettle fibre fine rope, strong string, coarse linen, sail cloth, sacking and binder twine. Sheets, cycle tyre covers, and fine material suitable for clothing can also be made, but have not as yet been produced in Denmark owing to lack of expensive delicate machinery.

THE PROTECTION OF WHEAT FROM WEEVILS.*

THE problems affecting wheat storage or, as it might be more accurately described, wheat preservation, are of extreme urgency in view of the prospect of a serious shortage in the food supply of the world as one of the results of the war, and it is obviously a matter of exceptional importance to prevent, as far as possible, the destruction and loss of grain in store through the ravages of pests.

Recognizing this, the British Government asked the Royal Society of London to arrange an investigation into the damage done by insects to grain in store, throughout the Empire.

The Executive Committee of the Commonwealth Advisory Council of Science and Industry received, through the Prime Minister's Department, in October 1916, a request from the Royal Society that a committee should be appointed in Australia to co-operate with similar committees in England and Canada in this investigation. Reports were obtained from the Government Entomologists of each State, and it was shown that considerable losses were caused annually in Australia from grain weevils and other pests. The Executive Committee thereupon appointed a special committee to make further investigations.

This special committee included Mr. Leo Rossell, representing the milling industry ; Professor W. A. Haswell, F. R. S., Professor of Zoology in the University of Sydney ; and Mr. W. W. Froggatt, Government Entomologist, New South Wales. Mr. F. B. Guthrie, Chemist to the Department of Agriculture of New South Wales, subsequently joined the committee. The progress report prepared by this special committee has now been published in Bulletin 5 of

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* Reprinted from the *Journal of the Department of Agriculture of South Australia* vol. XXI, no. 7, February 1918, p. 589.

the Advisory Council, and can be obtained post free from the Secretary, 314, Albert Street, East Melbourne.

The report indicates that only the two grain weevils (*Calandra granaria* and *C. oryzæ*) demand special measures on account of their destructive effects on stored grain, that the development of weevils in wheat and their increase in number may be checked by not using old bags which may be weevil-infested or storing in buildings likewise infested, and that bags of weevil-infested wheat should not be brought into contact or near that which is sound, for before wheat can become infested there must be a female to lay her eggs in the grains of wheat. It is only when the perfect insect, after going through the various stages of its larval existence, emerges through a tiny hole in the grain that the damage is evident, and except during the pupating stage destruction is going on during the whole life of the insect. Under suitable conditions it takes from 19 to 22 days from the egg to the adult beetle, and in three months, in one experiment, 40 weevils produced 3,056 descendants. Under the present system of handling wheat, the destruction of weevil, once it has gained access to the bagged grain, seems hopeless. Many methods of fumigating grain have been tried, and so far the most effective is that of poisoning with the fumes of carbon dioxide ; but with bagged wheat this is not applicable, save at a prohibitive cost. Sun-dried wheat contains only 4·7 per cent. of moisture. Neither in this nor in wheat as it emerges from the thresher with a moisture content up to 6·7 per cent. will weevil breed. With 8 per cent. of moisture they died in six weeks without breeding, at 9 per cent. they remained dormant, but with anything above the latter, provided they had free air, they became active and bred. It would thus appear that dry wheat stored in airtight bins is immune from the attack of weevils. Wheat when first bagged does not, under ordinary circumstances, contain sufficient moisture to enable weevils to breed ; therefore, unless moisture is added from without, the grain remains weevil-proof. Thus if stored in a fairly dry climate, completely protected from the weather, it is certain that wheat may be stored for an indefinite period without any damage from weevil.

THE IMPORTANCE OF MOLD ACTION IN SOILS.*

BY

DR. P. E. BROWN,

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THE development of soil bacteriology during the last decade has been truly remarkable. Many fundamental problems connected with the occurrence and activities of bacteria in soils have been attacked, and considerable progress has been made toward their solution. While much work still remains to be done along this line, results already secured show, in a rather definite way, the importance of bacterial action in soils from the fertility standpoint.

According to recent investigations, however, bacteria are not the only micro-organisms which exert an influence on soil fertility. Molds, protozoa, and algæ have been found quite commonly, and evidently their action, especially that of molds, must also be considered in determining the crop-producing power of soils. The subject of micro-organic life in the soil has therefore been considerably broadened and complicated.

The occurrence of molds in soils has been noted many times in the past in connection with bacteriological and other studies, and various investigations have dealt in a more or less general way with the action of these organisms. It is only within the last year, however, that an attempt has been made in a logical and comprehensive manner to study the occurrence, distribution, and activities of molds in soils, and to solve some of the fundamental

* Paper presented at the meeting of the Society of American Bacteriologists at New Haven, Conn., December 27, 1916, and printed in *Science*, vol. XLVI, no. 1182, dated 24th August, 1917.

problems which arise in connection with the growth of these organisms. The results secured at the New Jersey Agricultural Experiment Station, [1], [2], [3] not only furnish a basis upon which future experiments may rest, but they also indicate quite distinctly that the growth of molds in the soil may be of great significance.

The transformation of organic and inorganic compounds in the soil has long been considered the particular function of soil bacteria, but molds may also play an important rôle in such processes, and indeed it is conceivable that in some instances they may prove largely responsible for the simplification of complex soil materials.

It is not the purpose of this paper to review the previous studies on molds, for excellent bibliographies have been presented in the work of Waksman [2] and Coleman [1] already referred to. It is desired merely to call attention in a brief way to the varied action of molds in soils, and to present a compilation of various published data and some of our own unpublished results along this line, with the idea of emphasizing the need of further study of these organisms.

In the first place, the number of molds in soils should be considered, and while data along this line are far from conclusive, it has been shown that large numbers of these organisms are always present. Especially is this true for soils rich in humus and acid in reaction; but the occurrence of fungi is not restricted to such abnormal soils. Neutral, well-aerated, and well-fertilized soils are also found to contain rich mold floras. Furthermore, fungi are not limited merely to the surface soil, but occur in the deeper soil layers. The well-known predilection of certain fungi for acid conditions has been confirmed and leads to interesting conclusions regarding the special importance of these forms in acid soils in which beneficial bacterial action is largely restricted.

[1] Coleman, D. A. "Environmental factors influencing the Activity of Soil Fungi," *Soil Science*, vol. II, no. 1, p. 1.

[2] Waksman, S. A. "Soil Fungi and their Activities," *Soil Science*, vol. II, no. 2, p. 103.

[3] Waksman, S. A. "Do Fungi actually live in the Soil and produce Mycelium?" *Science* n. s. 44, p. 320.

A very important point in connection with the occurrence of molds in soils has been studied recently by Waksman.[1] While the counting methods employed have shown the large numbers of molds in soils, considerable doubt existed as to whether these counts represented the actual number of active fungi, or only the spores. If spores alone are present, the activities of molds in soils may be of less immediate importance, although their presence would indicate previous active growth as well as future activity when the soil conditions become satisfactory for the development of active forms from the spores. Active mold growth on the other hand would undoubtedly be of immediate importance in the chemical changes occurring in the soil. The value of definite information along this line is apparent. The careful experiments of Waksman show that many molds occur in soils in an active state as well as in the form of spores. While certain groups do not appear to be present in an active condition in the soils tested, although the plate method showed their occurrence as spores, studies of other soils may lead to different conclusions.

Conn[2] has attempted to check Waksman's results by the use of smaller quantities of soil, but was unsuccessful. Using 10 mg. of soil, he secured no growth of mold mycelia such as Waksman obtained with lumps of soil 1 cm. in diameter. He describes a direct microscopic examination of soils and finds no mold mycelia present. He concludes from these experiments that there is serious doubt whether molds exist in soils in an active form *in sufficient numbers* to be important compared with bacteria. There seem to be two questions involved here : How large a proportion of the number of molds developing on plates represent active forms and how many spores ? What is the number of active mold forms which need be present in the soil for them to be considered important in the various soil chemical processes ?

The first of these questions is rather difficult to answer at the present time, but our experiments indicate that rather a large

[1] *loc. cit.*

[2] Conn, H. J., "Relative importance of Fungi and Bacteria in Soil," *Science*, n. s. 44, p. 857.

proportion of the total number of molds present in various soils occur in the active state. We have found active mold growth occurring in all the soils thus far examined, and we have used both Waksman's and Conn's methods. Our results confirm Waksman's observations, therefore, and Conn's criticism seems unwarranted, for *active mold mycelia have developed in all our tests, using not only 10 mg. but also smaller quantities of soils, as well* as the larger lumps employed by Waksman. The soils tested are normal soils, many of them untreated and none extremely rich in humus.

Further work along this line is certainly desirable, but from our observations thus far there seems no doubt but that *fungi occur actively in soils*, and hence we feel that their action must be important, regardless of their relative numbers compared with bacteria. Furthermore, the presence of spores is likewise important, for they may become active in the near future and bring about their characteristic reactions. The answer to the second question mentioned above can only come after long-continued experiments, but from the vigorous action of molds noted in so many cases, as will be pointed out later, it is evident that the problem of micro-organic activity in relation to soil fertility cannot be completely solved without a knowledge of mold growth. Perhaps they are not as important as bacteria, there is no means yet of knowing, but even if of secondary significance they deserve recognition. Our present knowledge of soil fertility is too incomplete to permit us to pass over hastily any possibly important factors without thorough study.

We believe, therefore, that molds occur in most soils, both in the active and in the spore state, and hence they must pass through their various life-cycles in the soil. Furthermore, different soils undoubtedly have different fungus floras. Species present under one combination of conditions may be absent under others. Organisms present only as spores in one case may occur actively in other instances. Finally, it seems perfectly possible that the relative occurrence of active and spore forms of various organisms may vary in the *same* soil with varying conditions of moisture, temperature, aeration, reaction, and food-supply.

Considering the occurrence of molds in an active state in all soils an established fact, the importance of these organisms in the decomposition of the soil organic matter becomes evident. Many experiments have been conducted along this line, and it has been very clearly demonstrated that molds are very efficient ammonifiers. Indications have been secured that there exists a correlation between the biological stage of the organisms and the periods of ammonia accumulation. The largest amount seems to accompany the periods of spore germination, and the smallest amount the time preparatory to actual spore formation.

All the nitrogenous organic materials which make up the humus content of soils are easily attacked by various fungus forms and ammonia is liberated in large amounts. Part of this ammonia may, of course, be utilized by them; but by far the larger part is set free and may be subsequently nitrified for use by the higher plants. Various fertilizing materials containing complex nitrogenous compounds may be ammonified by soil fungi, and their decomposition considerably facilitated. For instance, experiments with cyanamide show its rapid transformation to ammonia by certain molds. Ammonia production from urea by molds has also been definitely proven.

The non-nitrogenous portion of the soil organic matter is also attacked by many molds. Thus experiments have shown that cellulose is rapidly decomposed by many species, and other substances such as sugars, pectins, oils, fats, waxes, organic acids, etc., are likewise broken down by molds. Some recent results secured in our laboratories show the large carbon-dioxide production by molds. No doubt therefore remains but that these organisms play an extremely important part in the decomposition of all soil organic matter and indeed certain results indicate that their action along this line may be much greater than that of bacteria, at least under certain soil conditions.

No experiments have yet been reported which indicate that molds may bring about nitrification, and this process, therefore, still appears to be purely bacteriological. Further experiments may modify this conclusion.

Denitrification and deazotofication, however, processes now known to be of slight significance in normal soils but which may occur in highly manured, specially treated greenhouse and market garden soils, may possibly be brought about by the action of molds. The introduction of these organisms with the manure used may be an important factor here. Definite data along this line are lacking at the present time.

Non-symbiotic nitrogen fixation, or azofication by molds, has been studied from time to time, and indications have been secured that certain species may be able to utilize the nitrogen of the atmosphere. The results as a whole, however, are far from satisfactory, and indeed the conclusion has been drawn that at the present time the "weight of the conclusions on the fixation of nitrogen by fungi seems to be on the negative side." Further experiments along this line are certainly desirable.

The utilization of various nitrogen compounds by molds has been studied to some extent, and it has been found that ammonia and nitrate compounds are assimilated by these organisms in considerable amounts. Thus under extreme conditions of mold growth it is conceivable that molds may be actual competitors with the higher plants for nitrogenous food materials. It is not believed, however, that such conditions would occur except very rarely. A knowledge of mold growth in soils may be of some significance, nevertheless, in connection with the questions involved in the fertilization of soils with nitrates and ammonium salts.

The decomposition of mineral compounds in soils by molds has been studied only to a very slight extent. Data secured in our laboratories, very largely in connection with certain chemical and bacteriological studies, indicate, however, that these organisms may play an extremely important rôle, not only in preparing nitrogenous food materials for plants as has been indicated, but also in making other mineral constituents available. Complete data along the various lines indicated will be published later.

Studies of the production of available phosphorus by bacteria and molds have shown the vigorous action of various fungi in this direction. Several experiments carried out by various methods

have shown that rock phosphate is apparently transformed much more rapidly into a soluble form by many molds than by bacteria. The importance of further study along this line in connection with the solution of the moot question regarding the relative merits of rock phosphate and acid phosphate can readily be seen.

The oxidation of sulphur in the soil, or sulfofication, a process which has recently received some attention and which gives evidence of being of great importance from the soil fertility standpoint, has been shown to be accomplished by several species of molds. The action of these organisms in this process may become of special importance in connection with the recent suggestion for the production of available phosphorus by composting rock phosphate, sulphur, and soil or manure.

The process of ferrification, or iron oxidation in soils, while largely chemical in nature according to results thus far secured, is brought about partly by micro-organisms, and certain molds are apparently much more active in this action than any of the bacteria studied.

Experiments on the production of available potassium by molds should also yield interesting results. No data have yet been secured on this point.

In fact, it seems evident that mold action in soils may be of far greater significance than has previously been supposed in preparing available food for plant growth. No longer should the study of micro-organic activities in soils consider bacteria alone. Mold action must also be investigated, and in most cases it is undoubtedly true that only vague, incomplete results can be secured if such mold studies are not included. Many results secured in bacteriological investigations might be explained and interpreted much more clearly and definitely if the activities of molds were considered.

If soil bacteriology is to be developed to the proper extent in the future, and the relation of micro-organisms to soil fertility is to be established with any degree of certainty, investigations must include not only bacterial action, but the activities of molds and possibly also the growth of protozoa and algæ.

It is certainly desirable that the investigations of molds in soils and their activities and importance be carried out much more generally and on a larger scale than is the case at present. Here is a field of study rich in possibilities and the importance of work along these lines cannot be questioned.

NOTES ON MOTOR CULTIVATION.*

BY

JOHN McLAREN, LEEDS.

As my name was mentioned in your paper last month in connection with the above matter, I take the liberty of sending you a few notes on the subject.

I have already expressed the opinion that trials of motor ploughs, in which British makers are unable to compete, are to be deprecated at the present time. All the English firms are over head and ears in munitions work, and can take no part in any such demonstrations during the continuance of the war. Of course, if the needs of the British agriculturist can be promptly and efficiently supplied by American makers, not even the British manufacturers would object, as we all recognize the importance of increasing our home food production. But in this case experts in land cultivation are satisfied that the British needs are not, and cannot be, satisfactorily met by the American product in which the commercial note, rather than the mechanical instinct, is the more obvious.

I take exception to the complacent assumption that any of the American tractors even approximately meets the requirements of British agriculture. If their efficiency and durability were on a par with the commercial skill with which they are boomed it might be different. British agriculturists are invited to take altogether too much on trust. Fortunately the results are not likely to be so financially disastrous to agriculturists as they would have been a year or two ago, seeing our farmers are now doing well, and most of them can afford to pay for their experience.

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* Reprinted from *The Implement and Machinery Review*, October 1, 1917.

I state as a fact that motor-ploughs so-called, by which I mean ploughs hauled direct by internal combustion engines, have not been successful anywhere. In Canada where they have had the best chance, they have only done moderately, and even there, I believe, farmers are now returning to steam tractors. But even although they had been highly successful in Canada and elsewhere, it does not at all follow that they are as well suited for this country where farming conditions are essentially different. In most of the countries where motor tractors have been largely used the principal industry is corn growing, with little or no rotation of crops. Farmers are content to turn the sod over to a depth of 3 or 4 inches, and they require nothing of what we understand by the word "cultivation" in the proper sense of the word. There is nothing to correspond with our rotation of crops, and the land is never worked as in this country for cleaning or preparing the ground for root crops.

In our moist climate, moreover, the land is seldom suitable for carrying heavy motors, and it is quite an exceptional year where it remains hard enough to carry them for more than a very short season. Experience tells us that only heavy tractors are suitable for this country, because it is little use purchasing motors unless they can haul more than a two or three-furrow plough in light land as this can easily be done by horses. All the correspondents, even Mr. S. F. Edge, desiderate a light motor, but they naively confess that the trouble with light motors is that the wheels spin round and have not sufficient adhesion. It must be obvious to everyone that adhesion depends more upon weight than on power, and in order to haul even three or four furrows in moderately heavy land a motor of a minimum weight of 5 tons is essential.

In this country we require the land worked as well as ploughed, which involves cross-ploughing, cultivating, dragging and harrowing, and, in spite of all assertions to the contrary, this work cannot be done properly, efficiently, and economically by motors crossing and re-crossing the ploughed land.

I believe, in the last 50 years, about three million acres of land has either been laid down to grass or has laid itself down, and the problem to-day is to get this three million acres back again into

cultivation as quickly as possible. In the early seventies, before agricultural depression set in, there were thousands of sets of steam ploughing tackle in England and Scotland. They were of various systems, some worked by single and others by double engines. Most of them were owned by the farmers themselves, and they were practically all commercially successful. The changed conditions of agriculture in this country stopped all development of steam cultivating machinery, and as the tackle wore out it was not replaced, so that previous to the outbreak of war there was very little steam ploughing tackle in this country at all. When the food question became acute the Government realized the importance of the position, and set to work with the best means in their power to tackle it. The importation of immense quantities of American tractors appeared to them the best method of meeting the abnormal situation.

I am not going to criticize in a carping or unfriendly spirit the action of the Government who did what seemed to them best in a sudden emergency. The fact that mistakes were made is neither here nor there, because no great scheme can be carried through on the spur of the moment without serious mistakes, and if the result on the whole is satisfactory the public will not very seriously condemn any errors of judgment which may have been committed. The task before the Department was immense. Time pressed, and brooked no delay. Horses were not available. All our British engineers were engaged on munitions, and the most virile and capable of our man-power had either joined up or were conscripted to the colours. Seeing that we had practically no resources at home, there was no alternative but to look abroad, and the result we can all see.

It may be that the apparatus requisitioned by the Government has been helpful in meeting and tiding us over a sudden crisis, and if so we must not complain, but it is not to be thought of as a permanent solution of the question which faces us in the future.

Although British agriculturists, in years of cheap corn, allowed steam ploughing in England to die out, there has all along been a large business done in the manufacture of steam cultivating tackle for abroad, where it has been used for the production of corn to supply

food to Great Britain, whose rulers did not care a straw for agriculture and under whose policy it promised to become a lost art. There is therefore an immense amount of expert opinion and experience available if the Government choose to utilize it ; and it is very important that they should do so without delay, otherwise the country may come to the conclusion that these internal combustion tractors represent the last word and the final solution of the problem. But this is really not so, and it is obvious to all who are experienced in the cultivation of the land that there is a great danger of a wrong lead being given to our agriculturists in this matter. There is no reason why British agriculturists should not consult and take advantage of the practical experience of others, instead of purchasing it over again at their own expense. The old facts will be no more valuable to the country at large for having been discovered and proved afresh at a large expenditure of money and time.

But I do not wish to assume the rôle of a merely destructive critic. I should like in these notes to say something indicative of what I think would be the proper solution to the problem, which I may restate as follows :—(1) To turn over the three million acres of land in the least possible time and at the least possible expense ; (2) to make provision for working at the land and preparing a seed bed either for cereals or roots ; (3) economy of man-power. I do not care how this is done, whether by direct traction or by double engines (cable system worked by steam), or by internal combustion engines working on any system whatever. For the purposes of this letter I will assume that the whole three million acres have to be broken up by mechanical means, owing, if you like, to the shortage of horses. The figure is not important. Any other figure will do, as my conclusions will run out in the same proportion whatever figures we take as the basis of our calculation.

Assuming that the whole of this work was to be done by motor tractors such as we see being introduced at present, I suppose a liberal allowance per motor would be 300 acres of ploughing per season. This would mean 10,000 motors, at £350 per set, including ploughs—or £3,500,000 capital expenditure. From all the information

I can gather a cost of 30*s*. per acre would be considered a very favourable result, taking the average of all the motor sets put to work in the last two years, so that the cost of ploughing three million acres by motor at 30*s*. per acre would be £4,500,000. Each of these motors would require at least one skilled man to drive and attend to it. Many of them would require two men, so that I estimate at least 15,000 men would be required to work these 10,000 motors. But, in my opinion, the number required would be even more than that. Here, then, we have at least 15,000 men required to do the work, at a total cost of £4,500,000.

On the other hand, assuming the work of a pair of double engines at 3,000 acres per year, we should require 1,000 sets of tackle, costing, say, £3,500 per set. This runs out to £3,500,000, or exactly the same capital expenditure as for the motors. An outside figure of cost would be 15*s*. per acre, so that the cost of ploughing three million acres by double engines would be £2,250,000 —a difference in favour of steam of exactly one-half (£2,250,000). But the number of men called for to work the steam ploughing tackle would be only 2,000 skilled and, at the outside, 4,000 unskilled, making a total of 6,000 men required for the steam as against 15,000 for the petrol tractors.

Moreover, at the end of five years the bulk of the petrol tractor will be on the scrap-heap, and we shall be fortunate if at the end of that period 20 per cent. of them (or their depreciated equivalent) representing £750,000,are at work ; whereas with the double engine cable system the engines will be almost as good as new, but, even allowing 20 per cent. for depreciation, they would represent a value of £2,625,000, which is probably the most important fact of all.

I have confidence in submitting these figures to the judgment of practical men, and do not think it is necessary to argue the question further. I shall be told that the tractor will do a great deal of farm work in addition to ploughing. In many cases it will and in many cases it will not ; but whatever it earns in this way will only go a very small way towards the upkeep and redemption of the disappearing capital.

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STEAM AND MOTOR CULTIVATION.

THE remarks of Mr. John McLaren on motor cultivation, published in another column, are particularly welcome at the present moment, because they help to bring into proper perspective a generally distorted view of the rôle of motor tractors. When the value of the ploughing tractor first began to be recognized there was no suggestion that it would do the work efficiently accomplished by steam ploughing tackle, and if all the farms were of such size as to allow of the profitable use of steam ploughing sets there would never have been any question of employing motor tractors. It is because the vast majority of the farms, especially on the Continent, are of such moderate dimensions as to preclude the use of steam ploughing tackle that it was hoped to make up for the deficient supply of horses and men by the introduction of motor machines. Since the outbreak of the war the problem has become so serious that the economy of the motor tractor is of less importance than the necessity to till every available acre of land for the production of food-stuffs. This cannot be done by steam ploughing, or by horses, because there is not a sufficient number of them, and motor tractors are therefore the only machines available for the purpose. Their value is enhanced in a time of stress, whereas, if the necessity of cultivating the land were not so great, there would be plenty to say about the shortcomings of many of the existing types of motor tractors. These machines are anything but perfect, and there are some notable failures due to an ignorance of the limitations of the motor tractor and to a want of organization for enabling agriculturists to keep their machines in good running order; but the tractor must be employed to put the available land under cultivation; and, while doing useful work in a time of emergency, it is preparing the way for an accumulation of practical experience which should be valuable to tractor designers after the war. Many of the direct ploughing tractors now in the use are inefficient, and few can plough three furrows to a depth of a foot, while on stiff clayey soil they are frequently unable to go deeper than a few inches. On some soils, and on very hilly land, they are sometimes hopeless, and this is one

of the weak points of the tractor, which should be so designed as to be capable of ploughing to a suitable depth on all kinds of soil. Still, in the present condition of the agricultural industry, the tractors are rendering a great service in tilling large areas of land that otherwise would be allowed to lie fallow. When conditions change after the war the tractors will have to be designed on quite different lines, preferably with chain tracks, for after all the question is mainly one of reducing the dead-weight as much as possible and distributing it over a considerable area of contact with the soil. There is no doubt that the tractor in some form or another has come to stay, and its success after the war will depend upon its being improved, perhaps to a considerable extent, to meet the needs of agriculturists who have to till moderately-sized farms. The tractor can only be successful in two ways, either in being employed for purely tillage operations by contractors who operate over particular districts, or in adapting it to many kinds of farm work so that the agriculturist can purchase a machine with the certainty of being able to use it during the greater part of the year. Steam ploughing tackle does not come within this sphere of operations, nor can the tractor compete with steam when it comes to breaking up big lands or deep ploughing on large estates.

Notes.

Dr. C. A. Barber, Government Sugarcane Expert, Madras, writes in the January (1918) number of the *International Sugar Journal* on the **Origin of the Uba Cane** as follows :—

The reference in your September number to the origin of the Yuba or Uba cane, so largely grown in Natal, gives me an opportunity to put down certain notes which I have accumulated on this variety and which may be of interest to those who cultivate it. I have grown it now for a considerable number of years on the Cane-breeding Station at Coimbatore in company with a large assortment of indigenous Indian canes. The Yuba in the collection has been obtained direct from Natal. There is no doubt whatever that it is a Ganna cane of the Pansahi group of Indian canes, a series which is grown in many places from Assam to the Punjab, a distance of over 1,200 miles along the Himalayas, but it is perhaps best suited to Bihar where there are a number of canes of this group. I made some attempt at locating Yuba, but I failed completely in coming across any Indian language with *uba* in it. I have thus far collected the following varieties, differing from one another to a very slight degree :—Sadi Khajee said to come from Assam, Pansahi, Maneria, Lata, Chynia, and Ketari from Bihar ; Merthi, Dikchan, Sanachi, Baranga from the United Provinces, and Kahu from the Punjab. It is interesting to note its greatest development in Bihar, for this is on the border line between the regions where thick and thin canes predominate, and Ganna canes as a class are intermediate between the Paunda or thick tropical ones, and the Ukh or thin indigenous Indian canes. I must therefore first of all emphasize that Yuba is an indigenous Indian cane, leaving for the present the way in which it reached Natal, although I see that there is a strong presumption

from its history that it came from an Indian source. My main difficulty has been to find any connexion between the word Uba and any Indian language.

On a recent visit to Burma, I examined carefully all the canes collected on the farms and many in the fields. As in Assam and the Peninsula, thick canes grow very well in Burma and for a time I failed to get any indication of indigenous canes such as are grown in India occurring there. But on a visit to Hmawbi farm, I was shown a thin cane which is grown in Moulmein. They had fortunately, also growing, Yuba canes received from Natal. Now the first glance showed that the Moulmein cane was a member of the Pansahi group, and a little further examination also showed that there was no obvious means of distinguishing the Moulmein cane from the Yuba growing next to it. My language difficulty at once occurred to me, and I asked whether there were any other words in Burmese which sounded like Yuba. The reply was interesting : "Oh yes, of course, 'u-ba' means 'take it'." It is the usual answer of the polite Burman (who will give you anything) to any request made on going round his fields. So the following suggestion may be made. Governor Mitchell would very likely in those days leave a Burmese port when returning to Natal. He would see the canes and ask for a few, receiving the characteristic "u-ba" in reply. I give the suggestion for what it is worth, but would emphasize the fact that the cane in question is most certainly an Indian indigenous cane of the Pansahi group.

I have often wondered at its being grown in Natal and Queensland. It is a cane of poor sucrose content in India, but it is thickish as Indian canes grow. It is very resistant to salt in the soil as are all of its class, moderately fibrous, very luxuriant, and tillering well. But, under the ryot's cultivation, often on entirely unmanured and badly cultivated land, it and its class have suffered heavily from red rot (*Colletotrichum falcatum*) and have been displaced by thinner and more hardy canes over large tracts. Its use as a fodder I can readily understand in places where sorghum cannot easily be grown and grass is not abundant. It requires little water and is much easier to grow on poor land than the thick canes of the tropics,

especially where the climate is cold and the growing season short. But, where such canes are desirable and the rich thick canes of the tropics are grown with difficulty, I sometimes wonder whether India may not be able to provide a better cane for the mill. We do not regard the Pansahi class at all as our best indigenous varieties. On the Cane-breeding Station we have taken various members of the Pansahi group as parents in our crosses and have, I believe, succeeded in getting hybrids with tropical canes. The work is still in progress, but the luxuriance and free tillering of the class makes it desired in this combination. The Natal planters would be well advised to try a number of thin canes of good sucrose content which we have already obtained on the Cane-breeding Station, and I shall be happy to send consignments if they wish it.

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TEN YEARS OF AGRICULTURE THROUGHOUT THE WORLD.

In dealing with the statistics of agriculture, even more particularly than in reviewing those relating to other matters, the wide variety of crops, of climate, of terms employed, makes it exceedingly difficult to draw up any estimates of production that are beyond cavil. In the course of the nineteenth century many efforts were made to accomplish this aim, but in order to reach a practical and tangible result it became necessary to create a central organization of high standing, specially arranged for the collection and scientific classification of the very miscellaneous data which are published in so many parts of the world. This central organization is the International Institute of Agriculture, Rome, so well known to competent authorities by its numerous publications, and has just issued a new work dealing on a complete and accurate basis with the world's agriculture.

This volume is the *International Year Book of Agricultural Statistics, 1907 to 1916*, and is the most exhaustive work in existence on agricultural statistics, as it is the result of very extensive and detailed research devoted to this study.

Comprising over one thousand pages, the 836 statistical tables are replete with every sort of information upon the subjects considered, thus establishing the volume as one of very great importance.

The number of agricultural products embraced is very large and those of tropical countries have received as much attention as the crops of the temperate zones have secured.

In due sequence are furnished all the available data regarding areas cultivated in each country, the total yields realized, and the yields obtained on a given standard of area. Besides all this the Year Book includes the five years' and ten years' averages for the period included, so that readers can ascertain at a glance whether in any particular year cultivation has extended or has been restricted in a given country and whether the results have been favourable or the reverse.

The first products to be considered are the cereals as naturally being of capital importance for food, the very basis of human requirements inasmuch as they furnish our daily bread.

We find that the ascertainable annual yield of wheat throughout the world exceeds a thousand million quintals, and represents at present value more than two thousand millions sterling ; the yield of maize is nearly as large as that of wheat and is worth one thousand millions sterling, while the aggregate value of the six chief cereals (wheat, rye, barley, oats, maize, and rice) is not less than six thousand millions sterling, or thirty billions of dollars, yearly.

The yield of potatoes is over fifteen hundred million quintals, and that of sugar beet is more than five hundred million quintals. Every year the world has at disposal a total of 150 million quintals of beet and cane sugar, nearly 150 million hectolitres of wine, 10 million quintals of coffee, more than 8 millions of leaf tobacco, nearly 1 million quintals of hops.

Textile industries account annually for nearly 50 million quintals of cotton, 8 millions of flax, 7 millions of hemp, while silkworm breeders in Europe and Asia deliver to the trade more than 200 millions in cocoons. The raw material for vegetable oils comprises yearly throughout the world an aggregate of 30 million quintals

of olives, and a similar quantity of linseed, 4 millions of hempseed, and 5 millions of rapeseed.

Turning to live stock, we find in the Year Book, for each of the ten years comprised, the numbers of horses, asses, cattle, sheep, pigs, etc., in 82 countries taken singly, and afterwards reckoned out as compared with each thousand inhabitants of the country, both at the opening and at the close of the period under review. The results reached in these tables are of the greatest interest. It appears that in Uruguay there are eight head of cattle to each inhabitant, in Argentina more than four head, in Australia more than two head, and throughout South America about two head per inhabitant, while in the United States and Canada there is one head of cattle per person, and in Europe only one to two persons.

Having given, by means of a large number of tables, the imports and exports of the products previously considered as to yield, and shewing the origin and destination of these imports and exports as regards each country, the Year Book takes up the question of consumption, also for each country.

It is worth while to note that the consumption of wheat per head of population is extremely large in Australia, in Canada, in France, in Argentina, etc., while it is very limited in Japan, British India, Egypt, Sweden, etc., as the inhabitants of these countries live chiefly upon rice, maize, rye, or other articles of food.

The prices of the chief products, on spot and for forward or future delivery, form a special chapter where readers will find all the data for a detailed examination of the marked fluctuations in recent years, inasmuch as weekly quotations are recorded in respect of the chief products. This chapter comprises tables of rates of freight and of exchange.

Then follows a chapter on fertilizers and chemical products employed in agriculture, including the data of production, trade, and consumption, with the quotations for phosphatic, potassic, and nitrogenous fertilizers, for sulphur and sulphate of copper. These materials give rise to a very large and active trade, since many of them are only to be found at certain spots, and therefore whole fleets are in request for their transport to the localities where they are

consumed. This is particularly the case with natural phosphates and with nitrate of soda.

At the conclusion of the Year Book there is a special chapter where readers can ascertain the authority for each of the data, and are thereby enabled, if they so desire, to consult these authorities and to verify the figures.

This important work is indispensable for all who wish to study any point connected with agriculture or with the trade in agricultural products. It has its special place on the desk of the economist, of the agricultural engineer, of the merchant, of the manufacturer, of the statesman, in short of all who are interested in the progress and well-being of nations.

The price of the volume is 8*s*, or $2. It is available at the Service des abonnements et publications de l' Institut International d'Agriculture, Villa Umberto, Rome, Italy.

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THE **Water Hyacinth,** which has become so great a pest in Bengal and Burma that it has been found necessary in the latter province to pass a special law to deal with it, has also been found in the neighbourhood of Gurdaspur. It is said that its introduction there a few years ago was due to a Deputy Commissioner who wished to beautify his tank. It spread over the tank with great rapidity, and passing cultivators, attracted by its beauty, took away plants to put in their own tanks which in turn it soon covered. It is of course impossible that the plant should ever be the pest here (in Punjab) it apparently is in more watery provinces, but the attention of the members of the local agricultural association has been directed to the necessity of doing what they can to prevent it spreading.—[*Punjab Agricultural Notes*, March, 1918.]

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THE COTTON-SEED INDUSTRY.

THE development of the Indian cotton-seed trade practically dates from the beginning of the present century, and the annual production of cotton-seed in India is now estimated at 1,870,000 tons,

of which 1,168,000 tons are available for cattle food and crushing purposes. The Indian seed belongs to the class known as white or fuzzy seed as it has on it a double layer of fibre, the underlayer of fluff or lint and the outer layer of true cotton fibre. The seeds, as they come into the market, contain considerable quantities of impurities and also about 8 per cent. of damaged seeds, these being due to careless ginning. The composition of a number of Indian seeds gives an average of 19·67 oil, 34·68 meal, and 45·65 of husk and lint. Indian seed is valued in this country on the basis of 18 per cent. of oil, but there is evidence to support the percentage being raised. The most effective treatment of the cotton-seed for storage and the prevention of fermentation appears to be to delint it immediately after ginning, and remove all light and broken seeds, and thoroughly clean them and sterilize them by hot air blasts in vertical cylinders or spiral conveyors on the counter-current principle. Seeds thus treated and stored in a dry godown, or in silos, keep well for a very long time and yield excellent products. With regard to the extraction of oil, the best method for Indian seed is the mixed decorticated plan. The American practice is to remove the lint, decorticate the seed, and then crush the kernels separately, but it is better to modify this process by the admixture of a certain percentage of ground hulls with the kernels. The very small oil-content of the seed has made it necessary to devise means to obtain a maximum yield of oil from the seeds, and various proposals with a view to this object being attained have been tried. The refining of the crude oil is also a process of importance in this respect.

Of the by-products, the hulls are the most important, being utilized as fertilizers, feeding stuffs, and as raw materials for paper-making. Next in importance is the liquid residue or foots. This has been used to produce colouring matter, paint, soap, stock, shellac substitute, and, with a considerable admixture of other substances, as a leather substitute. The lint separated in the preliminary process is used for making paper, cotton oil, gun cotton, celluloid, artificial silk, etc. There are still a few problems to be solved in connection with the Indian cotton-seed industry, and, besides the desired increase in the oil-content, the separation of the

fluorescent substance found in the oil is desirable, and the effect of cotton oil on press cloths of different types invited consideration.

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A strong seed-crushing industry should be established in this country, so that the fertilizing by-products might be returned directly to the land from which they had been derived.—[*Indian Industries and Power*, vol. XV, no. 6.]

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THE **Statistics** compiled by the Government of India from the Reports **of the Provincial Civil Veterinary Departments** for the year 1916-17 reveal the great expansion of the departments and the wider appreciation of the good work done by them during the last twelve years. The expenditure of over Rs. 31 lakhs during the year as against some Rs. 10 lakhs in 1904-05 shows that Government is fully aware of the importance of cattle to India inasmuch as without them agriculture would be at a standstill, and in spite of his innate conservatism the Indian peasant has not been slow to take advantage of the greater facilities provided for keeping his faithful slaves at the plough in fit condition. Though the number of dispensaries increased from 269 to 463 (an increase of 72 per cent. only), the number of animals brought for treatment rose from 256,014 to 954,599 (an increase of nearly 300 per cent.). The number of animals treated and castrations performed by peripatetic veterinary assistants similarly increased by about 200 per cent. (from 258,718 to 750,948). Inoculation, once so dreaded, has grown so popular that, whereas twelve years ago owners of only 75,269 cattle could be persuaded to allow their animals to be treated, last year the owners of as many as 644,841 were found to be believers in the immunity afforded by the various sera manufactured at the Muktesar Laboratory. That this increasing confidence has not been misplaced will be apparent from the fact that in a year in which 255,418 animals died from contagious diseases, only 2,668 died after inoculation out of more than 600,000 treated.

Improvement of stock by maintenance of stud bulls and horse and donkey stallions, cattle-breeding farms and holding of fairs and shows, is another line of activity of the Department. The number of stud bulls, owned both by Government and local bodies, rose from 1,197 in the previous year to 1,357 during the year under review, but it is a pity that local bodies, outside the Punjab and parts of the United Provinces, have not yet realized their usefulness in this direction. The receipts of cattle farms amounted to Rs. 1,60,078 of which the Hissar farm alone contributed Rs. 1,24,853. Two hundred and seventeen cattle fairs and shows were held during the year and 24 medals and prizes worth Rs. 18,645 were awarded.

It is clear that to cope with the increasing amount of work thrown on the Department as the result of a growing appreciation on the part of the cultivators and others, more rapid provision of the supervising staff and trained subordinate staff is required. It appears however that the career of a veterinary assistant does not appeal to the professional classes of some provinces at least, as in spite of liberal provision of scholarships and almost a sure chance of getting an appointment at the end of the training the number of entrants in veterinary colleges and schools is so limited. Rs. 4,18,571 were spent on veterinary instruction during the year, but the number of students turned out at the end of the year as qualified for employment as assistants was only 137 for the whole of India.—[EDITOR.]

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SPIKE DISEASE IN SANDALWOOD.

THE *Indian Forester* for February (1918) has two interesting papers on the subject of spike disease in sandalwood, the root cause of which remains as elusive as ever. There is no hint of its being eradicated from any area in which it has established itself, but there are always ominous accounts of its cropping up even in practically isolated spots. In the Kollimalai Hills, for instance, we are told there was no trace of the disease up to the middle of 1912; in

April, 1914, a single sapling was discovered to be infected; in October of the same year a number of young trees had been found to be attacked and some dead, and so the Forest Officer had all the diseased trees he could find uprooted. The spread of the disease was, however, not arrested. The extraordinary feature of the disease is that it appears in isolated patches—in the Kollimalai Hills there were two affected areas eight miles apart, while the intervening tract remained unaffected. More remarkable still is the fact that the nearest previously known spiked area from the Kollimalais was 80 miles away and no explanation is forthcoming as to how this distance was bridged. The idea is beginning to gain ground that the disease is endemic and spontaneous and may be spread by seed. It is remarkable that though first discovered in Coorg in 1899 and closely studied ever since, no progress has been made in arresting the disease.—[*Indian Engineering*, March 16, 1918.]

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SILK CULTURE IN INDIA.

The trade in raw silk from India has seriously decreased within the past fifty years, largely in consequence of the deterioration of the Bengal cocoon and inferior reeling. At the present time the main quantities of Indian silk are grown in Kashmir where sericulture is a State monopoly. Kashmir ordinarily produces each year about 1,400 bales of 150 lb. each. The silk is grown on the Himalayan foothills at an altitude of 6,000 feet. It is regular, well-reeled, and although slightly weaker in the thread than Italian silk, nevertheless compares favourably with the Japanese qualities. The greatest care is taken to prevent disease in the cocoons. Good seed is imported each year from the Cevennes district of France, and reproduction is not allowed.

The silk is reeled within the borders of the State, and although there is some export of cocoons to Italy, there is no reason why the whole of the season's crop should not be reeled in Kashmir. The production of cocoons is large and could be extended, but increased

facilities for reeling under European supervision are required in order to secure the advantages of the low-priced and comparatively highly-skilled labour. The Kashmiree is a skilful operative, and with European supervision, the reeling is almost as good as the Japanese.

The prospects for the extension of sericulture in India are promising. It must be borne in mind that the finest qualities of silk which the world produces are grown in the hilly districts of countries like China, Japan, and Italy, the climate and altitude apparently producing nerve, strength, and vitality in the fibre grown on the hills which is not apparent in the silk produced on the plains.

There is little doubt that the foothills of the Himalayas lying within the United Provinces and the Punjab and the States of Bhutan, Sikkim, and Nepal, are as well adapted to sericulture as those lying within the State of Kashmir. The population of these districts is almost equal to, and the area is considerably greater than, the whole of Japan. The main desideratum is a spirit of enterprise similar to that shown by the Government of Kashmir, and it would appear that efforts should be made by the Indian Government to encourage the development of sericulture within this large area.

Within the past two years sericulture has been commenced within the State of Patiala on a small but definite basis under the supervision of a native graduate of the Montpelier School in France. The first parcels of raw silk which have reached this country have been declared by experts to be fully equal to the best Kashmir silk.

The Bengal export trade has almost ceased. The cocoon is not a good one, and careless reeling produces an irregular silk only suited for coarser manufactures. There is little doubt, however, that were the industry developed under qualified supervision, a greatly improved quality would be produced.—[*Report on Silk and Silk Waste by the Departmental Committee appointed by the Board of Trade.*]

INDIGO CESS ACT.

THE following Act of the Indian Legislative Council received the assent of the Governor-General on the 6th March, 1918 :—

ACT NO. III OF 1918.

An Act to provide for the levy of a cess on indigo exported from British India.

Whereas it is expedient to provide funds for the promotion of research in the interests of the indigo industry in India ;

And whereas for this purpose it is expedient to levy a cess on indigo produced in India and exported from British India ; It is hereby enacted as follows :—

Short title and commencement.

1. (1) This Act may be called the Indigo Cess Act, 1918 ; and

(2) It shall come into force on the first day of April, 1918.

Imposition of duty on exports of indigo and preparations thereof.

2. (1) There shall be levied and collected on all indigo produced in India and exported from any customs-port to any port beyond the limits of British India or to Aden a cess at the rate of one rupee per maund of $82\frac{2}{7}$ pounds avoirdupois :

Provided that, where any preparation of indigo mixed with any other substance for use as a dye is so exported, the cess shall be levied on such proportion of the total weight of such preparation as the Governor-General in Council may determine by rule under this Act.

(2) In this section the expression "customs-port" has the same meaning as in the Sea Customs Act, 1878, VIII of 1878, and the cess levied shall be deemed to be a customs-duty for the purposes of Section 5 of the Indian Tariff Act, 1894 (VIII of 1894).

3. The proceeds of the cess collected under this Act shall be applied to meet the cost of such measures as the Governor-General in Council may consider it advisable to take for promoting research in the interests of the indigo industry in India.

Application of proceeds of cess.

4. The Governor-General in Council may make rules consistent with this Act—

Power to make rules.

(*a*) for regulating the method of assessing, levying and collecting the cess;

(*b*) for prescribing the particular purposes to which the cess may be applied; and

(*c*) generally for carrying out the purposes of this Act.

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It is notified that **Cess** at the rate of one rupee per maund will be levied, with effect from the 21st May, **on all Indigo exported from Travancore** to any port outside British India or to Aden.

***

RULES FOR DISINFECTION OF PLANTS.

In exercise of the power conferred by sub section (1) of section 5 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Bengal Government has made the following rules for the disinfection of plants in respect of which Notification No. 13-C.,[1] dated the 7th November, 1917, has been issued under sub-section (1) of section 3 of that Act, by the Governor-General in Council, namely :

1. It shall be the duty of the Customs staff to conduct the operation of disinfection of plants on their entry at the port of Calcutta.

2. The fumigation of plants on their entry at the port of Calcutta with hydrocyanic acid gas shall be in accordance with the instructions received from time to time from the Imperial Entomologist, Pusa.

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[1] See *The Agricultural Journal of India*, vol. XIII, part II, p. 359.

REGULATION OF IMPORT OF PLANTS BY POST.

A NOTIFICATION, dated 15th December, 1917, issued by the Government of India in the Department of Commerce and Industry, says :—

In exercise of the powers conferred by section 25 of the Indian Post Office Act, 1898 (VI of 1898), as amended by Act III of 1912, the Governor-General in Council is pleased to empower the postal officers noted in the margin to search, or cause search to be made, amongst all articles in course of transmission by post to any place in British India, for living plants and all portions thereof (including seeds and fruits) the import of which by sea or land into British India is prohibited, regulated or restricted by the Notification in the Department of Revenue and Agriculture No. 13-C.,[1] dated the 7th November, 1917, and to direct that the said officers shall deliver all postal articles reasonably believed or found to contain such goods to the nearest Customs Collector.

1. The Presidency Postmaster, Deputy Postmaster and Assistant Postmasters at Bombay.
2. The Postmaster and Deputy Postmaster, Karachi.
3. The Presidency Postmaster, Deputy Postmaster and Assistant Postmasters at Calcutta.
4. The Presidency Postmaster, Deputy Postmaster and Assistant Postmasters at Madras.
5. The Postmaster and Deputy Postmaster, Dhanushkodi.
6. The Postmaster, Negapatam.
7. The Postmaster, Deputy Postmaster and Assistant Postmasters at Rangoon.

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IN continuation of the Department of Revenue and Agriculture Notification No. 13-C. publishing rules issued by the Governor-General in Council under section 3 (1) of the Destructive Insects and Pests Act, 1914 (II of 1914), printed in the last April issue of this Journal, it has been decided that the licenses required, under section 10 of the Notification, for the **importation of flax seeds and berseem** (Egyptian clover) **seeds into British India by sea** should be granted to the consignees by the Provincial Department of Agriculture only after the Department has satisfied itself that the seed has been obtained through well known and reliable seed merchants and has been guaranteed free from dodder seeds.

[1] See *The Agricultural Journal of India*, vol. XIII, part II, p. 359.

PERSONAL NOTES, APPOINTMENTS AND TRANSFERS, MEETINGS AND CONFERENCES, ETC.

THE Birthday Honours' List contains the following which will be of interest to the Agricultural Department :—

To be C.S.I. The Hon'ble Mr. Henry Stavely Lawrence, I.C.S., Commissioner in Sind, Bombay (formerly Director of Agriculture, Bombay).

The Hon'ble Mr. Llewellyn Eddison Buckley, I.C.S., Commissioner of Revenue Settlement, Survey, Land Records and Agriculture, Board of Revenue, Madras.

To be C.I.E. Dr. Charles Alfred Barber, Government Sugarcane Expert, Madras.

Nasarwanji Navroji Wadia, Esquire, Bombay, Member of the Indian Cotton Committee.

Khan Sahib. M. Mahommad Ikramuddin, Farm Overseer, Agricultural Research Institute, Pusa.

Rao Sahib. Chintamani Srinivasa Gopaul Krishna Rao, B.A., Superintendent, Office of the Agricultural Adviser to the Government of India, Pusa.

THE names of the undermentioned have been brought to the notice of the Government of India for valuable services rendered in India in connection with the war up to the 4th August, 1917.

Mr. J. Mackenna, C.I.E., I.C.S., Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa.

Mr. D. A. D. Aitchison, M.R.C.V.S., Principal, Madras Veterinary College, Madras.

Mr. K. Hewlett, Principal of the Veterinary College and Hospital, Bombay.

Mr. N. N. Wadia, Mill Owner, Bombay (Member of the Indian Cotton Committee).

Colonel J. Farmer, C.I.E., Chief Superintendent, Civil Veterinary Department (Punjab).

Mr. W. C. Renouf, I.C.S., Political Agent, Bahawalpur (formerly Director of Agriculture, Punjab).

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Mr. T. F. Main, B.Sc., Deputy Director of Agriculture, Sind, was granted, in Bombay Government Order No. 5372, dated 7th May, 1918, combined leave up to the 6th July, 1918, made up of privilege leave for one month and 7 days and special leave for the remaining period. He availed himself of the leave with effect from the forenoon of 4th June.

Mr. Gul Muhammed Abdul Rahman, Divisional Superintendent of Agriculture in Sind, has been appointed to act for Mr. Main.

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Lieutenant-Colonel G. K. Walker, C.I.E., F.R.C.V.S., Superintendent, Civil Veterinary Department, Bombay Presidency, has been granted privilege leave for three months in combination with furlough for three months, with effect from the 30th March, 1918, or the subsequent date on which he may avail himself of it.

Mr. G. Taylor, M.R.C.V.S., Indian Civil Veterinary Department, Punjab, has been appointed to officiate as Superintendent, Civil Veterinary Department, Bombay Presidency, during the absence of Lieutenant-Colonel G. K. Walker on leave or until further orders.

***

Mr. G. A. D. Stuart, I.C.S., Director of Agriculture, Madras, was granted privilege leave for one month from or after the 1st May, 1918.

The following arrangements were made in consequence of the grant of this leave :—

Mr. R. W. B. Cecil Wood, M.A., Principal and Professor of Agriculture, Agricultural College, and Superintendent, Central Agricultural Station, Coimbatore, to act as Director of Agriculture, Madras.

Mr. William McRae, M.A., B.Sc., Government Mycologist, Madras, to act as Principal of the Agricultural College, Coimbatore.

Mr. D. Ananda Rao, B.Sc., Assistant Professor of Agriculture and also Assistant Principal of the Agricultural College, to act as Professor of Agriculture and Superintendent of the Central Agricultural Station, Coimbatore.

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Mr. R. D. Anstead, Deputy Director of Agriculture for Planting Districts, was granted privilege leave for one month from 1st April, 1918.

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Mr. W. McRae, M.A., B.Sc., Government Mycologist, Madras, was granted privilege leave for one month with effect from or after the 2nd June, 1918.

M. R. Ry. S. Sundararaman Avargal, M.A., Assistant in Mycology, was appointed to act as Government Mycologist during the absence of Mr. W. McRae.

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M. R. Ry. D. Balkrishna Murti Garu, Assistant Director of Agriculture, 1st Circle, Madras Presidency, has been appointed to act as Deputy Director of Agriculture and to continue to be in charge of that circle.

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Mr. G. R. Hilson, Deputy Director of Agriculture, I, II and III Circles, Madras Presidency, has been appointed to be Deputy Director of Agriculture, II and III Circles.

Dr. R. V. Norris, M.Sc., A.I.C., formerly Physiological Chemist, Muktesar Laboratory, has been appointed to the Indian Agricultural Service, and posted to Coimbatore as Agricultural Chemist to the Government of Madras.

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The combined leave for one year granted to Mr. N. S. McGowan, Professor of Agriculture, Sabour College, has been cancelled.

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Mr. G. Milne, I.C.S., Director of Agriculture, Bihar and Orissa, is appointed to be the Director of Civil Supplies, Bihar and Orissa, in addition to his own duties. He is also appointed to be Custodian of Enemy Property during the absence on deputation of Mr. B. A. Collins or until further orders.

***

Mr. C. Somers Taylor, B.A., Offg. Principal of the Agricultural College at Sabour and Agricultural Chemist to the Government of Bihar and Orissa, has been granted privilege leave for two and a half months from 1st May, 1918, or any subsequent date on which he may avail himself of it.

Babu Manmatha Nath Ghosh, Assistant Professor of Physics and Chemistry, Sabour Agricultural College, is appointed to hold charge of the current duties of the Agricultural Chemist to the Government of Bihar and Orissa in addition to his own duties during the absence on leave of Mr. Taylor.

Mr. N. S. McGowan, Professor of Agriculture, Sabour College, has been appointed to officiate as Principal of the College during the absence on privilege leave of Mr. Taylor.

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The services of Mr. B. A. Collins, Registrar of Co-operative Societies, Bihar and Orissa, and Controller of Munitions, Bihar and Orissa Circle, are placed temporarily at the disposal of the Government of India, Indian Munitions Board.

Mr. R. W. D. Willoughby, I.C.S., Registrar, Co-operative Societies, United Provinces, has reverted as Deputy Commissioner, Second Grade, and has been posted to Kheri.

Shaikh Maqbul Husain, Khan Bahadur, C.I.E., Joint Registrar, Co-operative Societies, United Provinces, officiates as Registrar, *vice* Mr. R. W. D. Willoughby.

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Mr. H. M. Leake, Economic Botanist to Government, United Provinces, and Officiating Principal, Agricultural College, Cawnpur, was granted privilege leave for 20 days with effect from the afternoon of 10th June, 1918.

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Mr. Jatindra Nath Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, on special duty at Cawnpur, was granted privilege leave for one month and 13 days with effect from the forenoon of 3rd April, 1918.

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Mr. A. W. Fremantle, formerly Principal, Agricultural College, Cawnpur, has been permitted to retire from the Indian Agricultural Service.

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The work of the Punjab Department of Agriculture has increased so much that a second Director has been sanctioned for the period of the war. The Hon'ble Mr. C. A. H. Townsend, who was the Director of Agriculture and Industries of the Province, has made over the Agricultural Section to Mr. E. A. Joseph, I.C.S., and retains the portfolio of Industries himself.

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Mr. G. Evans, Deputy Director of Agriculture, Central Provinces, has proceeded to Mesopotamia on special duty in connection with the development of agricultural resources there.

Mr. C. P. Mayadas, Assistant Director of Agriculture, Southern Circle, Nagpur, is transferred in the same capacity to the Western Circle, Akola.

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The services of Mr. T. Couper, M.A., I.C.S., Director of Agriculture, Burma, have been placed at the disposal of His Excellency the Commander-in-Chief.

Mr. A. E. English, C.I.E., I.C.S., Commissioner on special duty, is placed in charge of the current duties of the Office of Director of Agriculture, Burma, in addition to his own, *vice* Mr. T. Couper.

The Local Government has also directed him to assist the Registrar, Co-operative Societies, Burma, in addition to his other duties, and has conferred upon him all powers of a Registrar under the Act.

***

The services of Mr. E. Thompstone, Deputy Director of Agriculture, Burma, are placed at the disposal of His Excellency the Commander-in-Chief in India with effect from the 1st May, 1918.

Mr. F. J. Warth, M.Sc., Agricultural Chemist, who was appointed Assistant Commandant of Military Police last March, has temporarily reverted to the Agricultural Department and is appointed to officiate as Deputy Director of Agriculture, *vice* Mr. Thompstone.

***

The services of Maung Ba Gyaw, Temporary Engineer, Public Works Department, who was appointed as an Agricultural Engineer, Burma, have been re-transferred to the Public Works Department of the Province with effect from the 17th May, 1918.

***

The following officers have been appointed to serve on the Food-stuffs Sub-Committee of the Central Transport and Food-stuffs Board formed at the headquarters of the Government of India

and presided over by the Hon'ble Sir Claude Hill, Member-in-Charge of the Department of Revenue and Agriculture :—

(1) Mr. E. A. Joseph, I.C.S., Director of Agriculture, Punjab;

(2) Mr. G. S. Henderson, Imperial Agriculturist, Pusa.

In addition to these the Agricultural Adviser to the Government of India will be co-opted on this Sub-Committee and that on Transport as occasion requires.

2. The functions of the Board will be to co-ordinate information and to suggest measures relative to the more efficient exploitation of India's resources in the matter of animal and mechanical transport and to collate information and advise the Government as to the measures calculated to develop the production of food-stuffs, to encourage local consumption of local products, and generally inculcate economy of resources in all directions.

Reviews.

A Handbook of Nature Study and Simple Agricultural Teaching for the Primary Schools of Burma.—By E. THOMPSTONE, B. Sc., Deputy Director of Agriculture, Burma. Pp. xi + 279 with 115 illustrations. (London: Longmans, Green & Co.) Price Rs. 2-8.

WE congratulate Mr. Thompstone on this handbook of nature study and simple agricultural teaching. Designed for the primary schools of Burma, it provides a model which should be easily adaptable for other provinces of India, and the lead having been given, we hope that agricultural officers in other provinces will follow the example set by Mr. Thompstone. The non-existence of suitable textbooks is the greatest handicap to the advance of agricultural education in our primary and middle schools. An effort must be made to remove this obstacle, for it is slowly but surely being borne in upon us that, if we are to make any impression on the agriculture of the country, it must be by the spread of general education amongst the agricultural classes, and that to popularize such education it must have an agricultural tinge or bias.

In his preface the author clearly expresses his aims. "This book," he writes, "is intended to be the means of—

(*a*) imparting to both teacher and pupil some knowledge of elementary agriculture and its importance;

(*b*) opening up to them some understanding of plant and animal life—giving them an insight into some of the fields of study—and of creating in them an interest in the common natural objects around them;

(*c*) instructing teachers how to give Nature Study lessons in a more life-like manner than that in which 'object lessons' are now given in schools."

The book opens with some very useful advice to teachers, notes on equipment, and some practical suggestions for studies. The main work is divided into sections dealing with plant-life, soils, crops, trees, birds, and insects. The language is simple, and each chapter ends with some practical instructions to teachers, which should considerably lighten the task of imparting knowledge. Finally the book is copiously illustrated.

Mr. Thompstone has given us a text-book which should serve as a useful model and should act as a powerful stimulus to Nature Study in the province of Burma, with particular reference to which it has been written.—[J. M.]

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The High Price of Sugar and How to Reduce it.—By HAROLD HAMEL SMITH. Pp. 54. (London: Bale, Sons & Danielsson, Ltd., Oxford House, 83-91, Great Titchfield Street, W.) Price 1*s.* net.

THIS booklet deals with the production within the British Empire, and more especially throughout India and the West Indies, of cane sugar which is a necessary article of food. The author points out that an increase in the production of this commodity can be brought about by fostering the growth of the sugar beet in the United Kingdom, but mainly by increasing the area and productivity of the cane-sugar-bearing lands in the Empire generally. If the British Empire in future is to be—and this war has shown us pretty plainly that she must be—self-supporting as regards her supplies of sugar it is necessary that not only should there be an increase in the area under cane, but also intensive methods must be applied. The actual or possible acreage available in the whole British Empire for this crop is roughly $5\frac{1}{2}$ million acres, and the average output of sugar per acre is barely $1\frac{1}{2}$ tons. Compare this out-turn with that in Java where 4 tons 6 cwt. of white sugar per acre is a normal thing, and then realize what scope there is for improvement in the British Empire. At present the world's shortage of sugar on account of the stoppage of beet sugar from enemy countries is about 2 million

tons. Given that we make it possible to get 2 tons of white sugar from an acre of cane, the $5\frac{1}{2}$ million acres within the whole British Empire should suffice not only to make good this deficiency but also to dominate the sugar market of the world.

The question now arises whether improvements are possible in the existing sugar industry in India with which we are most concerned. It can be said, without fear of contradiction, that if improved methods of cultivation including better manuring are adopted, and the huge losses which now take place in the manufacturing process in this country be cut, the total amount of sugar produced will make India not only free from her dependence on Java and Mauritius but also enable her to export some quantity. While we believe that, with the better varieties of cane being evolved by Dr. Barber at the Cane-breeding Station, Coimbatore, improved cultivation and the employment of less wasteful methods of extraction of juice and its conversion into sugar, there is every hope of establishing a successful sugar industry on a sound basis in India, we differ from the writer in the *Louisiana Planter*, quoted on page 17 of this booklet, that "the future of India lies for the present in the conversion of the sugar industry from the old farm crop with its soft *gur* sugar to a delivery of the necessary millions of tons of sugarcane to great central factories to be turned out there as pure sugars—white and nearly white." To any one acquainted with the local conditions this will at once be written down as impracticable in a large number of cases. India consumes not only white sugar but also *gur*. While we agree that the production of white sugar requires specially to be fostered, and there is plenty of scope for it, we must not lose sight of the existing *gur* industry which is also capable of considerable improvement. The two should in fact continue to exist side by side on account of India's peculiar requirements. Under expert guidance and proper organization they will materially help each other. But we need proper guidance from those best qualified to do so, and India should not allow the present opportunity to slip, as this is the most favourable time to put her house in order. Once it is clearly realized that the differences in the

various provinces in India regarding climate, crushing season, acquisition of land, etc., are very similar to those existing between, say, Louisiana and Cuba and Java, and that each province should pick out its counterpart abroad and religiously scrutinise its methods, then much work and waste of time will be saved and a material advance will accrue. India looks to the Government and the Agricultural Departments to point the way, so that capital may be attracted to this most important industry, and we welcome this publication as directing public attention to the possibility of developing the industry in this country at a time when the circumstances emphasize the necessity of increasing the output of this commodity in the Empire itself, so as to avoid the repetition of a similar experience in future.—[M. W. S.]

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A Survey of the Madras Dairy Trade.—By A. CARRUTH, Deputy Director of Agriculture, Live Stock, Madras. Department of Agriculture, Madras, Vol. IV, Bulletin No. 73. Printed at the Government Press, Madras. Price As. 8 or 9*d*.

IN Part I of this brochure, Mr. Carruth gives a lucid word-picture of the disgusting conditions under which milk which is sold to the general public in Madras is produced. It is quite evident that the writer found it difficult to restrict himself to ordinary everyday language in describing the state of the Madras cattle yards, and the following expression used in page 2 will convey some idea of the author's view of the conditions as he saw them :—

"One wonders that animals can live under such conditions, and that it is possible for any consumer of milk to escape being stricken by disease."

In Part II the methods of milking and cleansing milk vessels are described, and here also a sorry tale is told, everything being done just as it ought not to be done, and the essentials of common cleanliness entirely lost sight of.

Part III deals with the economic aspect of milk production as practised in Madras, and the author is to be congratulated on the very thorough and businesslike manner in which he has tackled this question. It is notable that in Madras where cows are more in evidence as milk producers than in Bombay, the buffalo proves a more profitable animal than the cow even on the basis of milk production for sale as fresh milk—that is, leaving out of account the extra butter fat contents of the buffalo's milk. The carefully compiled statistics given in this part of the pamphlet prove that the dairy industry in Madras is in a hopeless muddle from the commercial as well as the sanitary standpoint.

In the next chapter dealing with the quality of the milk sold, Mr. Carruth exposes the evils of the common Indian practice of driving the cow from door to door and milking at each customer's residence only that quantity which the purchaser requires. In describing the rounds of one particular cow, he shows that the first customer visited, who of course got the foremilk, was supplied with milk containing 1·8 per cent. of butter fat, whilst the last customer on the same round, who presumably paid the same price as the first, was given milk with 9 per cent. of fat.

The analyses given of milk actually purchased in the bazaar practically all show heavy adulteration, and here again the deplorable state of the industry is illustrated this time in a form which is of immense interest to the general public, as the figures prove the practical impossibility of obtaining pure milk in Madras.

Part V deals with the economic effect of the adulteration practised, and it is somewhat remarkable that even after allowing for the extra revenue from added water, the cow is still an unprofitable milk producer in Madras.

Chapter VI deals with the quantity of milk produced in Madras, and in the following chapter the author touches briefly on the cattle breeding problem in that city.

In the concluding general note the position generally is summarized, and the author does not attempt to solve the problem in detail, as he wisely states that this will require much thinking out.

The publication is perhaps the most concise and practical statement of the position of the dairy industry which has yet been published in India, and although it particularly deals with Madras, unfortunately like conditions exist to a greater or lesser extent in most of our large cities, and a study of the facts published and conclusions drawn will repay any one interested in the milk problem or the dairy industry generally. In the interests of the industry, it is to be hoped that Mr. Carruth will in due course publish the result of his "thinking out" the remedies. As this pamphlet shows, he has thoroughly grasped the present situation, and having correctly diagnosed the disease, he is in the proper position to prescribe the cure.—[Wm. S.]

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Establishment and Management of the Dairy Farm.—By Rao Bahadur G. K. Kelkar. Bombay Department of Agriculture Bulletin No. 86 of 1917.

The title of the pamphlet claims a good deal more than could possibly be condensed into a brochure of this size, and it may therefore be looked upon as hints relative to the establishment and management of a dairy farm in Western India. Throughout the booklet Mr. Kelkar is very brief, and in his attempt to condense the information to be imparted, in some cases omits important factors bearing upon the point he is discussing. Chapter I introduces the subject, and in Chapter II points to be considered before starting a dairy farm are discussed. Here Mr. Kelkar is on the right lines in advocating the production of city dairy supplies remote from urban areas where land and fodder are cheaper and where much better sanitary conditions exist, but unfortunately he does not touch on the problem of transit; it is somewhat vague to state that the farm must be situated somewhere near a big city or town. Does he mean within 20 miles or within 300 miles, as, given proper transit facilities, fresh milk, cream, and butter can be produced at either distance and sold fresh daily in any of our big cities.

In the third chapter Professor Kelkar gives some very interesting figures as to average weights, prices and yields of various classes

of dairy cattle known in the Western Presidency. These figures are accurate and may be taken as a sure guide by the prospective dairy farmers. Mr. Kelkar very wisely refrains from mentioning the "so many seers per day" cow which we hear so much about, but gives average yearly returns.

The various points to be noted in selecting the various classes of cattle are carefully described, but here again, Mr. Kelkar is too brief. He dismisses the vital subject of the importance of the sire in the herd with three brief lines. Indian dairymen, if ever they are to do anything to improve the dairy breeds of the country, must realize above all things the importance of breeding only from a first-class sire. A cow only produces, say, 8 calves in a lifetime. A stud bull may sire 300 to 400.

In closing Chapter III, reference is made to crossing Indian cattle with imported sires, and it would have added to the value of this publication if the author had dealt with the advantages and disadvantages of this system from the Indian point of view.

Chapter IV gives a deal of useful information concerning the buildings required on a modern dairy, and a plan is appended showing the lay-out of a dairy farm, giving the relative position of one building to another. It would have been advantageous if a few large-scale sketches showing details of construction, cross-sections of different types of cattle-sheds, etc., had been given. Working drawings could not very easily be prepared from the information provided.

In Chapter V the important subject of feeding is dealt with on sound lines, but the great importance of feeding always a proportion of green fodder to cattle in milk is dismissed with a line. In an appendix (C) referred to in this chapter a scheme for the production of a continuous supply of green fodder for a milking herd is given, and it is surprising in view of latter-day results to find no mention of Rhodes grass in this.

Chapter VI deals with the care of animals, and the ration recommended for calf-rearing seems somewhat meagre. In this chapter it would seem that the author might with advantage have said

something about the very important point of weaning calves at birth and milking the dam without the presence of the calf.

Chapter VII is headed "Milk products," and deals with milk, its production and distribution, cream, butter, *ghi*, and various Indian food preparations made from milk. It is a pity the author does not emphasize the importance of correct cream ripening in connection with butter-making; this is vastly important in India where so much inferior butter is made from over-ripe cream.

Chapter VIII disposes of that all-important subject "Cleanliness in the dairy," and in it the author does not even mention the value and importance of scalding utensils, etc., with live steam.

Chapter IX outlines the establishment necessary for a dairy of a certain size.

Chapter X gives correct and useful information as to records which should be kept, and in the following chapter a complete and useful list is given of the requisite plant, utensils, and furnishings for a dairy of a certain size.

In Chapter XII the author summarizes what he terms the business aspect of the dairy industry, and his figures will be found to be a safe basis for working on in connection with the results to be obtained from a milk-supplying dairy farm in the Deccan.

In the appendices details of the forms recommended for use in keeping records, dimensions of buildings, list of cultivating implements, average yields of various classes of fodder, analyses of feeding stuffs, estimates of plant for a milk-collecting station, and other useful and carefully compiled information is given.

The Bulletin generally is practical and useful, and the pity is that Mr. Kelkar did not give the public the benefit of a little more of his undoubted knowledge of the subject.—[Wm. S.]

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We have received from the Department of Agriculture, Mysore, a **Bulletin** recently issued **on the Cultivation of Areca Palm** in that State.

It is well known that next to the coconut, areca is economically the most important palm grown in India, almost every part of it being used in one form or another. The tree is practically confined

to India, Burma, and the Malay Peninsula and Archipelago, and from this area the world's demand for areca-nut is supplied. The total area under it in Mysore is nearly 42,500 acres, and the value of the crop is approximately 54 lakhs. The Bulletin gives useful information regarding the cultivation, manuring, and harvesting of the crop as also its diseases and pests. Experiments with a view to improving the quality and quantity of the crop by manuring and selection work are in progress on the Marthur farm, and as the yields vary from 10 maunds in Bangalore to 40 to 50 maunds in the better gardens in Shimoga, there seems plenty of scope for improvement in the crop.

This Bulletin is the first of a series in which it is proposed to discuss the present position and future possibilities of the more important crops of the State. This line of work is most useful, and we commend it to the notice of the Agricultural Departments in British India, for an accurate survey of existing agricultural conditions must precede any improvements of value.—[EDITOR.]

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The **Mysore Agricultural Calendar for 1918** maintains the standard of its previous issues. Though quite a small publication of 64 pages, it contains a lot of useful information. The opening pages give a list of the full staff of the Department and a brief description of the departmental farms and their work, in which we notice the success of the Department's investigations on *ragi* (*Eleusine coracana*) and sugarcane. Besides monthly notes, there are ten very useful and instructive articles, among which those on the Dairy Herd on the Hebbal Farm and Sericulture in Mysore are of more than local interest. As the Calendar is also issued in vernacular and the price is nominal (only an anna), there is likely to be a good demand for it among the classes for whose benefit it has been issued.—[EDITOR.]

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Journal of the Indian Economic Society, Vol. I, No. 1, March 1918, Bombay. Annual Subscription Rs. 5.

WE extend a welcome to this quarterly issued by the Indian Economic Society of Bombay. In the editorial foreword the object

of the Journal has been defined as being—(1) to strive to stimulate and focus the energies and thoughts of all those persons who are interested in the promotion of the economic advancement of the Indian people, (2) to discuss from time to time problems concerning the economic development of the country, and (3) to assist in the formation and dissemination of correct views on all economic questions.

In the section of Articles there are papers on (1) The Indian Budget for 1918-19, by Prof. Kale of the Fergusson College, Poona, (2) The Village in the Melting Pot, by Professor Gilbert Slater of Madras, (3) The Organization of Research in India, by Mr. Mazumdar, and (4) Capital and the Rate of Interest after the War, by Mr. M. J. Antia.

Among these the two of particular interest to those connected with the agricultural development of India are the one on the village in the melting pot in which Prof. Gilbert Slater throws some new light on the important question of fragmentation and excessive subdivision of holdings and the other on the organization of research in India by Mr. Mazumdar which is a powerful plea for the promotion and organization of scientific research in this country. We wonder whether Mr. Mazumdar is aware of the existence of the Board of Scientific Advice in India which co-ordinates the work of Government Scientific Departments in India or the Board of Agriculture which does the same work for Agricultural Departments in this country, as we find no reference to them in the article at all.

The next section is devoted to notes on (1) Railway Nationalization, (2) Indian Companies Restriction Act, (3) The Bombay Rent Act, (4) Treasury Bills, (5) Gold Mint, (6) War Finance and Transfer of Funds, and (7) The Bombay Revised Financial Statement. These are followed by a review article on "Mr. Russell and the Reconstruction of Society" which is interesting reading.

The concession granted to *bonâ fide* students in the matter of subscription (Rs. 3 instead of Rs. 5) is substantial and will, we hope, be availed of by students who have taken up Economics as their subject in the University.—[EDITOR.]

We have received from the Grihastha Publishing House of Calcutta a brochure on the **Anatomy of Silkworm and Moth** by Mr. M. N. De, Sericultural Assistant, Agricultural Research Institute, Pusa. It is a booklet of 25 pages in all, with nine text figures. As its name implies, it gives a description of the four stages (egg, larva, pupa, and moth), as also the internal and external organs, of the species *Bombyx mori*. The price is As. 6.– [Editor.]

Correspondence.

HANDLING YOUNG STOCK.

To the Editor,

The Agricultural Journal of India.

Sir,

My experience in India is entirely in accord with the view expressed by Mr. R. Cecil Wood in his letter in the current issue of your Journal.[1]

One of the most necessary characteristics in a milch-cow is that of docility, and I have found that in order to rear milking stock with this quality it is essential that the animals should be tied up and fed by hand daily, practically from birth. In the Military Dairy Farms we use different breeds of Indian dairy cattle and find this practice beneficial with all.

Poona:
April 10, 1918.

Yours faithfully,
W. Smith.

DENSITY OF INDIAN COTTON BALES.

To the Editor,

The Agricultural Journal of India.

Sir,

Professor Todd[2] is legally right when he says no mention is made on page 126 of Indian bales. The book is entitled "The World's Cotton Crops" and deals mainly with the economic side.

[1] *The Agricultural Journal of India*, vol. XIII, part II, p. 368.

[2] *loc. cit.*

Any one reading it and trying to form "*impressions*" would certainly think the Egyptian system of baling and pressing is the best in the world. India gets no praise anywhere. I would draw attention, *e.g.*, to page 20 where it is stated that "bad handling of the lint and seed in picking and *afterwards* have degraded Indian cotton to the lowest position in the cotton-growing world." I should not have mentioned this book except for the fact that Professor Todd has been in India since it was written and has lectured on Indian cotton before the Society of Arts, without however drawing any attention to "pressing" and "baling," which is one item at least in which most parts of India are ahead of the rest of the world.

LYALLPUR:
January, 1918.

Yours faithfully,
W. ROBERTS.

THE PROBLEM OF SUGAR MANUFACTURE IN INDIA.

Mr. A. E. Jordan has sent us a further contribution on this subject for publication. His letter and Mr. Wynne Sayer's reply thereto have been held over till October on account of pressure on our space.—[EDITOR.]

NEW BOOKS

ON AGRICULTURE AND ALLIED SUBJECTS

The Future of Our Agriculture, by Henry W. Wolff. (London: P. S. King and Son.) Price 12*s*. 6*d*. net.

Manual of Milk Products, by William A. Stocking, Professor of Dairy Industry at Cornell University. Illustrated. (London: Macmillan & Co., Ltd.) Price 10*s*. 6*d*. net.

Late Cabbage from Seed until Harvest: also Seed Raising, by E. N. Reed. Pp. xiii + 131. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 6*s*. net.

Greenhouses: Their Construction and Equipment, by W. J. Wright. Pp. xvi + 269. (New York: Orange Judd Co.; London: Kegan Paul & Co., Ltd.) Price 1.60 dollars net.

Food and Garden, by H. A. Day. (London: Methuen & Co.)

The Principles and Practice of Pruning, by M. G. Kains. Pp. xxv + 420. (New York: Orange Judd Co.) Price 2 dollars net.

The Scientist's Reference Book and Diary—20th issue for 1918. (Manchester: Messrs. Jas. Wooley, Sons & Co., Ltd.) Price 2*s*. 6*d*.

A Laboratory Manual of Farm Machinery, by F. A. Wirt. Pp. xxii + 162. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 6*s*. net.

Liquid Fuels for Internal Combustion Engines, by H. Moore. Pp. xv + 200. (London: Crosby Lockwood & Son.) Price 12*s*. 6*d*. net.

Allen's Commercial Organic Analysis. Fourth Edition, entirely re-written. Vol. IX. Edited by W. A. Davis. With Index for all the Volumes. Pp. xviii+836. (London: J. & A. Churchill.) Price 30*s*. net.

The Chemistry of Farm Practice, by S. E. Keitt. Pp. xii+253. (New York: J. Wiley & Sons, Ltd., Inc.; London: Chapman & Hall, Ltd.) Price 6*s*. net.

A Course in Food Analysis, by Dr. A. L. Winton. Pp. ix+252. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 7*s*. net.

Principles and Practice of Milk Hygiene, by Professor L. A. Klein. Pp. x+329. (Philadelphia & London: J. B. Lippincott Co.) Price 12*s*. 6*d*. net.

Annual Reports on the Progress of Chemistry for 1917. Issued by the Chemical Society. Vol. XIV. Pp. ix+264. (London: Gurney & Jackson.) Price 4*s*. 6*d*. net.

The Organism as a Whole from a Physico-chemical Viewpoint, by Dr. Jacques Loeb. Pp. x+379. (New York and London: G. P. Putnam's Sons.) Price 2.50 dollars.

The Wonders of Instinct, by J. H. Fabre. Translated by A. Teixeira de Mattos and B. Miall. Pp. 320. (London: T. Fisher Unwin, Ltd.) Price 10*s*. 6*d*. net.

Insects of Economic Importance: Outlines of Lectures in Economic Entomology, by Glenn W. Herric, Professor of Economic Entomology, Cornell University. (London: Macmillan & Co., Ltd.) Price 5*s*. 6*d*. net.

School Entomology, by E. D. Sanderson and L. M. Peairs. Pp. vii+356. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 7*s*. net.

Rustic Sounds and other Studies in Literature and Natural History, by Sir Francis Darwin. (London: John Murray.) Price 6*s*. net.

Secrets of Earth and Sea, by Sir Ray Lankester. (London: Methuen & Co.)

A Text-Book of Mycology and Plant Pathology, by John W. Harshberger, Ph.D., Professor of Botany, University of Pennsylvania. (London: J. & A. Churchill.) Price 15*s*. net.

Soil Biology, by Dr. A. L. Whiting. Pp. ix + 143. (New York: J. Wiley & Sons, Inc.; London: Chapman & Hall, Ltd.) Price 6*s*. net.

Originality: A Popular Study of the Creative Mind, by T. S. Knowlson. Pp. xvi + 304. (London: T. W. Laurie, Ltd.) Price 15*s*. net.

Lectures on the Principles of Symmetry and its Application in all Natural Sciences, by Professor F. M. Jaeger. Pp. xii + 333. (Amsterdam: "Elsevier" Publishing Co.)

The Electron: Its Isolation and Measurement and the Determination of some of its Properties, by Professor R. A. Millikan. (University of Chicago Science Series.) Pp. xii + 268. (Chicago, III: University of Chicago Press; London: Cambridge University Press.) Price 1.50 dollars net.

Veterinary First Aid and Horsemastership in the Service, by Major H. J. Axe, Army Veterinary Corps. Pp. 484. (Allahabad: The Pioneer Press.) Price Rs. 5.

Veterinary Obstetrics, by Professor W. L. Williams, New York State Veterinary College. Pp. xiv + 637. (Ithaca: Published by the Author.) Price 5 dollars.

Strangeways' Veterinary Anatomy, revised and edited by I. Vaughan. Tenth Edition. (Edinburgh: W. Green & Son.) Price £1 4*s*.

Essentials of Veterinary Physiology, by D. Noel Paton. Second Edition, revised and enlarged. (Edinburgh: W. Green & Son.) Price 12*s*. net.

Practical Bacteriology, Microbiology and Serum Therapy (Medical and Veterinary), by A. Besson. Translated and adapted from the Fifth French Edition by H. J. Hutchens. (London: Longmans Green & Co.) Price 37*s*. 6*d*. net.

Clinical Veterinary Medicine and Surgery, by P. J. Cadiot, Professor of Surgery at the Veterinary School of Alfort. Translated, edited and supplemented with 49 new articles and 34 illustrations by Jno. A. W. Dollar, M.R.C.V.S., F.R.S.E. Pp. 619. (London: Gay & Hancock, Ltd.) Price 15*s.* net.

Diseases of Cattle, Sheep, Goats and Swine, by G. Mossu, Professor at the Veterinary College of Alfort and Jno. A. W. Dollar, M.R.C.V.S., F.R.S.E., M.R.I. Pp. 785. Price 25*s.* net.

The Camel and Its Diseases, being Notes for Veterinary Surgeons and Commandants of Camel Corps, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. Pp. 148 with 48 illustrations. (London: Baillière, Tindall & Cox.) Price 5*s.* net.

THE following publications have been issued by the Imperial Department of Agriculture since our last issue :—

Special Indian Science Congress Number of the *Agricultural Journal of India,* 1918. Price Rs. 2 or 3*s.*

Some Camel-feeding Experiments, by H. E. Cross, M.R.C.V.S., D.V.H., A.Sc. Price *As.* 2 or 3*d.* (*Pusa Agricultural Research Institute Bulletin No. 77.*)

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7. Bulletins issued by the Agricultural Research Institute, Pusa.
8. Books.

The following are the publications of the last two years :—

Report of the Agricultural Research Institute and College, Pusa (including the Report of the Imperial Cotton Specialist), for the year 1915-16. Price, As. 6 or 7*d.*

Scientific Reports of the Agricultural Research Institute, Pusa (including the Report of the Imperial Cotton Specialist), for the year 1916-17. Price, As. 9 or 10*d.*

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Report on the Progress of Agriculture in India for the year 1916-17. Price, As. 12 or 1*s.* 1*d.*

Proceedings of the Board of Agriculture in India, held at Pusa on the 7th February, 1916, and following days (with Appendices). Price, R. 1-2 or 1*s.* 9*d.*

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